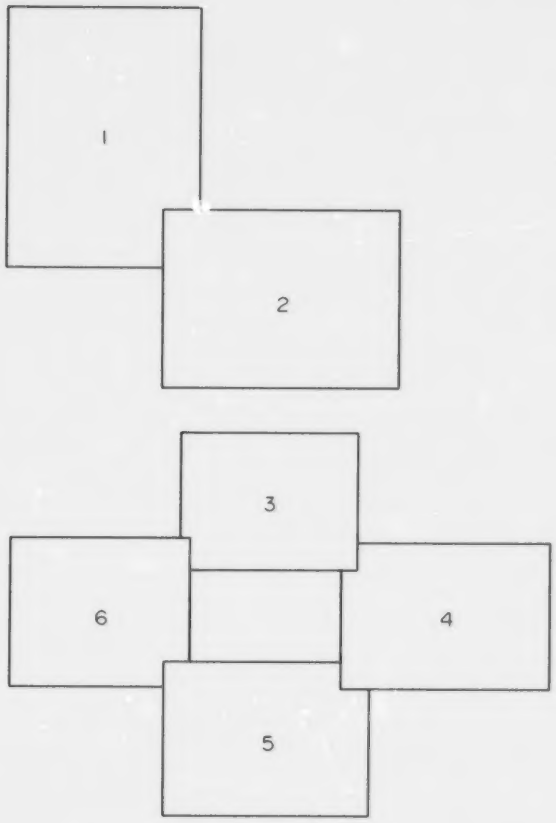
CANADA – NEWFOUNDLAND
MINERAL DEVELOPMENT AGREEMENT

PROJECT SUMMARIES

1984 – 1989

Canada

Newfoundland



1. *Research in a CANMET laboratory to improve processing of Labrador iron ore with spiral concentrators.*

2. *A geological-survey field camp at Makhavinekh Lake, Labrador.*

3. *Geoscientists collecting rock samples from the Roti Granite, southwestern Newfoundland; the Hope Brook Gold Mine is in the background.*

4. *A geoscientist using a computerized geochemical database to show the regional distribution of copper in Labrador.*

5. *Ore from Buchans Mine, consisting of banded chalcopyrite, sphalerite, galena, barite and pyrite.*

6. *A geoscientist doing a petrographic analysis of a thin section.*

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Compiled by
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Newfoundland Department of Mines and Energy

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ST. JOHN'S, NEWFOUNDLAND
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FOREWORD

This report summarizes the results of projects carried out under the Canada–Newfoundland Mineral Development Agreement (CNMDA), 1984–1989. The minerals agreement was one of several subsidiary agreements developed under the general umbrella of the Canada–Newfoundland Economic and Regional Development Agreement (ERDA).

The purpose of the Mineral Development Agreement was to provide a framework for joint planning of work that had the objective of strengthening and diversifying the mineral-resource base of the provincial economy. Projects were carried out by the Newfoundland Department of Mines and Energy and the Federal Department of Energy, Mines and Resources in four main program areas: Geoscience, Mining and Minerals Technology, Economic Development Studies, and Public Information.

The funding and delivery procedures established under the Agreement gave rise to three major groups of projects: those funded and delivered by Canada (identified by 'C' preceding the project number in this report); those funded and delivered by Newfoundland (identified by 'N' preceding the project number); and those funded jointly by Canada and Newfoundland and delivered by Newfoundland (identified by 'J' preceding the project number).

The results summarized herein indicate that the Agreement has met its objective of strengthening the mineral-resource base of the Province. The acquired geoscientific data have already led to increased exploration activity, and will form the basis for such activity far into the future. The geoscientific work has also led to the development of a new industrial-mineral operation, and other identified deposits are under active exploration.

Studies carried out under the mineral-technology program have resulted in increased recoveries in the iron-ore operations in western Labrador. Also, the studies have proposed possible improvements in mineral-processing technology at other mining operations–these will be investigated further by the companies involved. Economic studies have indicated a potential for development of silica deposits in Labrador and building-stone deposits on the Island. The economic-studies program also funded a Mineral Industry Assistance Program, which provided grants to prospectors and infrastructure assistance to several small mining operations in the province.

One of the most important accomplishments of the CNMDA was the development of an improved atmosphere of cooperation between the provincial and federal mineral-development agencies and the mineral industry, a cooperative atmosphere that will assist future development.

We express our appreciation to all those who have assisted in any way with making this Agreement the success it has been. In particular, we thank the many project leaders, both federal and provincial, on whose efforts that success is based.

P.W. Andrews
Co-Chairman
Canada

B.A. Greene
Co-Chairman
Newfoundland

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PROVINCIAL PROJECTS

1. GEOSCIENCE

J.1.8 INDUSTRIAL MINERAL STUDIES

J.1.8.1. Industrial Minerals (A.F. Howse)

Objectives. The purpose of the industrial-minerals project was to identify those commodities that, by virtue of their quality, reserves and location, have potential for economic development. The focus was primarily on marble and dolomite; other commodities investigated briefly were brick, shale and limestone.

Methods. Field work was carried out during the summers of 1985, 1986 and 1987. During 1985, reconnaissance sampling of all known marble occurrences in western Newfoundland was undertaken. In 1986, deposits at Penneys Pond and Coles Pond, near Roddickton, were mapped in detail and systematically sampled by diamond drilling. During 1987, further detailed exploration and sampling of the marble deposits near Roddickton were undertaken. A preliminary assessment of the Pinchgut Road Deposit south of Corner Brook was also completed.

The initial work in 1985 involved chip sampling all known marble occurrences in western Newfoundland. These samples were then chemically analyzed, and selected samples were tested for whiteness and brightness. By matching dry brightness with chemical composition, targets for a 1986 follow-up mapping and drilling program were selected. Several promising deposits were identified, the purest and whitest of which are located in the Canada Harbour–Roddickton area. In 1987, the zone of documented marble occurrences was extended as a result of the investigation of showings north of Coles Pond and west of Croque.

Approximately 600 chip samples were collected during the course of the 1985 survey. All were geochemically analyzed and 143 were subjected to additional tests to determine whiteness and brightness. In the subsequent diamond-drilling program, over 700 samples were geochemically analyzed, and 392 of these were tested for a range of physical properties including whiteness and brightness.

Dolomite investigations included sampling potential metallurgical-grade dolomite deposits in the carbonate sequences of western Newfoundland. Five major prospects were sampled together with several other occurrences. The five major prospects are located at Port au Port Peninsula, Goose Arm, Deer Cove, Port aux Choix, and Cape Norman. The sampling procedure consisted of chip sampling perpendicular to bedding over a maximum thickness of 5 m per sample. In areas of flat-lying bedding, it was locally only possible to sample the top bed. Approximately 370 samples were collected and analyzed for a range of chemical elements.

Results. The project identified two marble deposits having specifications that meet the standards required for premium-quality filler. These deposits, located at Penny's Pond and Coles Pond, near Roddickton, are now held by ECC America Inc. and Aurion Minerals Ltd., who are carrying out further assessment. In addition, the project led to the discovery of Aurion Minerals' Bonus Deposit, near Croque. This deposit is currently being developed. Other companies who have acquired properties in the marble belt as a result of the project are Vermont Marble (OMYA) at Canada Harbour and Lacana Minerals, who have staked claims north of Coles Pond.

Plate 1. *White marble from the Lower Ordovician St. George Group, Coles Pond area, near Roddickton.*

Analyses of samples from the dolomite survey show that there are two areas on the Great Northern Peninsula containing dolomite reserves of potential metallurgical grade. These areas are located at Back Arm near Port aux Choix, and near Cape Norman. A diamond-drilling assessment

would be required in order to confirm the surface-sampling results.

J.1.8.2. Marine-Placer Assessment (D.N. Proudfoot)

Objectives. The purpose of the marine-placer assessment project was to conduct a preliminary assessment of the potential of the Newfoundland nearshore environment for placer deposits, including the development of qualitative marine-placer models and an assessment of methodology. This project was designed to stimulate private-sector marine-placer exploration.

Methods. The first phase of the project was equally funded by C-CORE, and carried out during the 1987 field season. It concentrated on Port au Port Bay in the Fox Island River area. The area was chosen because it is relatively simple to model, having a single, easily identifiable bedrock source for light heavy minerals (chromite, zircon, monazite, rutile, ilmenite), a single sediment-transport conduit, and a partially sheltered bay that acts as a sediment trap because of its shape and orientation. These factors provided the best opportunity to develop and test marine-placer models. The study consisted of a geomorphic–surficial-geology analysis of Fox Island River area, marine surveys (including surficial-sediment sampling), bottom photography and seismic reconnaissance of the entire bay, and more site-specific seismic surveys. It involved about six person-weeks of field work by geologists and technicians, and several days of scuba-diver time.

The second phase, funded entirely by the CNMDA, was conducted by three marine sedimentologists at C-CORE. It involved an application of methodology and models developed in phase 1 to do a preliminary assessment of marine-placer potential for the nearshore of insular Newfoundland. This was an office study that involved the compilation, integration and interpretation of existing data relating to the formation of modern placers and the preservation of relict placers. These included potential onshore bedrock sources, Quaternary geology, drainage, sea-level history, coastal exposure, nearshore sedimentology and shelf gradient.

Results. In phase 1, six textural facies were defined and interpreted to be controlled by different hydraulic regimes and the character of primary and secondary sources. The distribution of heavy minerals is a function of enrichment processes that are controlled by the hydraulic regime. Reworked lag concentrations of heavy minerals occur in gravel interstices in the upper river, whereas differential entrainment has concentrated placer minerals in sands of the beach and offshore. The highest heavy-mineral concentrations occur in beach sands (up to 98 total-weight %) as discrete laminae and in modern marine sands (up to 32 total-weight %), whereas the lowest concentrations occur in the aggrading areas near the river mouth.

In phase 2, a genetic classification containing nine deposit types for high-latitude marine-placer deposits was developed. Deposits were classified based on the presence and nature of the source, the operative enrichment processes and the most favourable sedimentary environment. A method of evaluating high-latitude marine-placer potential was developed. The primary environmental factors are sea-level variation, sediment supply and marine energy. Using this system, the Newfoundland coast was subdivided into 12 unique marine-placer-potential zones.

Publication of phase 1 results led directly to the staking of claims in Port au Port Bay. This is the first marine-placer exploration attempt in Newfoundland. This area is now being evaluated by the private sector. Publication of the results of phase 2 has created further private-sector interest in marine-placer exploration. Staking for gold marine placers will likely occur in the near future.

J.1.9 GEOLOGICAL MAPPING

J.1.9.1 Strange Lake (A.B. Ryan)

Objectives. This project focused on a 60-km-wide corridor (NTS 14D/South) between the central Labrador coast near Nain and the Quebec border near the Strange Lake rare-metal-enriched peralkaline granite intrusion. The project had several goals, viz. (i) to produce a 1:100,000-scale map of a transect across the Nain Province–Churchill Province boundary and the plutonic rocks that intrude it, (ii) to attempt to identify within the known plutonic rocks any peralkaline compositions, (iii) to survey for intrusions of peralkaline granite similar to Strange Lake within the lesser known surrounding gneiss terrane, and (iv) to assess the economic potential of all rocks in the project corridor. The project goals were to be achieved by a combination of 1:50,000- and 1:100,000-scale geological mapping, with subsequent petrological and geochemical analyses of the major rock types and economically interesting zones.

Methods. Investigations in 1985 were conducted from a seven-man helicopter-supported base-camp; two 1:50,000-scale NTS map areas (14D/1, 8) were completed between July 11 and September 1 by two two-person traversing teams. During 1986 and 1987, the project operated from two nine-person base camps and several fly-camps each season, mapping three 1:50,000-scale map areas each year utilizing three two-person traversing teams. NTS map areas 14D/2, 6, 7 were completed in 1986; 14D/3, 4, 5 and parts of 24A/1, 8 were mapped in 1987.

The traversing teams were equipped with hand-held scintillometers to help detect anomalous radioactivity (as at Strange Lake) and sampled the most prominent gossan zones in the area for post-season assay for base and precious metals. Collaborative studies directly relating to the project are chiefly aimed at geochronology; some samples of rocks from the area have been dated by U–Pb methods and more studies are in progress. One B.Sc. thesis arose from the project.

Results. The project achieved its planned objective with respect to the geological mapping of the corridor. Adverse weather conditions throughout most of the 1988 season resulted in less-than-desired surveying of parts of the western end of the transect, but coverage is adequate enough for final 1:100,000-scale map publication. The mapping has enabled the unravelling of some complexities of the local geology and re-interpretation of some of the relationships inferred on the basis of earlier reconnaissance mapping. It has defined numerous Proterozoic(?) metasedimentary and metavolcanic (supracrustal) belts within the Churchill Province, and has outlined regions that appear to be remnants of Archean rocks along the western margin of the project corridor.

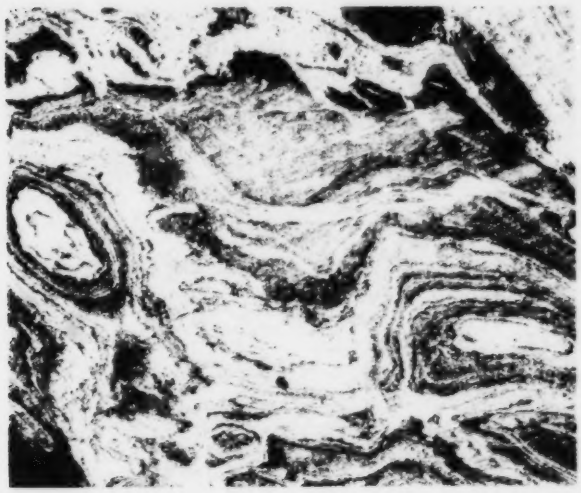


Plate 2. *Eye-like structures in metamorphic rocks near the Labrador–Quebec border, a result of Proterozoic deformation.*

The supracrustal sequences are locally characterized by extensive and conspicuous ochreous pyritic zones. Assays of samples collected from these zones during the survey yielded negligible amounts of base or precious metals. However, further sampling and analysis of such zones are warranted.

No peralkaline compositions were found within the known granitic plutons, nor were any new occurrences of such rocks found within the surrounding gneisses. A previously known fluorine water-anomaly is attributed to fluorite, an accessory phase in rapakivi granite in the general vicinity of the anomaly. A U–Th airborne anomaly appears to be due to monazite-rich granitic dykes in a supracrustal sequence; the host rocks are restricted in distribution and appear to have no economic potential.

J.1.9.2 Eastern Grenville (C.F. Gower)

Objectives. The purpose of the project was to continue mapping in the Grenville Province of eastern Labrador, specifically to complete 1:100,000-scale geological mapping of NTS map areas 13H/SW, 13H/SE, 13A/NE, 13A/SE, 3D/NW, 3D/SW, 3E/NW and 3E/SW. These map areas occupy a 80-km-wide coastal fringe and encompass an area of about 20,000 km².

Methods. Mapping was done by a helicopter-supported seven-person geoscientific crew plus helicopter crew. Data, in inland regions, were collected mainly by helicopter-positioned ground traverses at 3- to 6-km spacing, depending on terrain and outcrop-density factors. This database was augmented by helicopter traversing/landings conducted between ground traverses, and in poorly exposed areas. All coastline was also traversed on foot, except for some inaccessible sections. Traverses were carried out daily by three two-person teams, one person remaining in camp to process previously collected samples and to complete miscellaneous camp chores.

Results. The region is underlain by extensive tracts of dominantly pelitic metasedimentary gneiss, associated with psammitic gneiss, minor mafic volcanic rocks (including pillow lavas) calc-silicate rocks and quartzite. These supracrustal rocks are the oldest recognizable units and have been intruded by a wide range of 1680 to 1640 Ma mafic to felsic plutonic rocks. The mafic plutonic rocks are mainly gabbronoritic in composition, but also include anorthosite to monzonitic variants. The largest such body is the White Bear Arm complex, which has a strike length exceeding 150 km. The felsic plutonic rocks range from diorite (underlying most of the Earl Island domain) to granite, including extensive K-feldspar-megacrystic granodiorite. Younger felsic rocks, especially extensive Grenvillian plutons, occur in the southern part of the area. Post-Grenvillian rocks include Late Precambrian redbeds, mafic volcanic rocks and mafic dykes, and Carboniferous dykes.

Apart from the mapping itself, major scientific results have been obtained on several fronts, in particular, regional tectonic analysis, geochronology, paleomagnetism and metamorphism.

During regional tectonic analysis, southeast extensions to the previously identified Groswater Bay, Lake Melville and Mealy Mountains terranes have been delimited, and two new terranes recognized; the latter are now referred to as the Hawke River and Pinware terranes. In addition to being delimited by structural criteria, such as bounding mylonite zones or contrasting structural trends across terrane boundaries, these terranes show lithological differences, distinct geophysical expressions, metamorphic contrasts and specific geochronological signatures.

Continued U–Pb geochronological investigations have demonstrated that, apart from the Pinware terrane, the region is underlain by rocks of Labradorian age (1680 to 1645 Ma). In the Lake Melville and Groswater Bay terranes, these were modified by Grenvillian tectonism at ca. 1040 to 1030 Ma and ca. 980 to 970 Ma respectively. The Hawke River and Mealy Mountains terranes largely escaped the effects of Grenvillian tectonism, except adjacent to their margins. South

Plate 3. *Quartz diorite (foreground), dated at 1668 ± 2 Ma, is intruded by early, very deformed (centre-right) and later, less deformed (top) mafic dykes. Both dykes are intruded by pegmatite (Partridge Bay area, south of Batteau).*

of the Mealy Mountains terrane boundary, Grenvillian plutonism is extensive, especially in the Pinware terrane.

Paleomagnetic work has documented the paleomagnetic characteristics of pre-Grenvillian, Late Precambrian and Carboniferous mafic intrusions in southeast Labrador. Most of the pre-Grenvillian intrusions have Grenvillian paleomagnetic characteristics, but some results suggest that an earlier paleomagnetic signature may be preserved in places. In both cases, paleomagnetic studies on the Late Precambrian and Carboniferous dykes were accompanied by geochronological studies, resulting in well-defined paleopole positions for the region at those times.

Metamorphic studies have quantified metamorphic conditions in parts of the mapping region. T. Van Nostrand has confirmed high-pressure and high-temperature conditions in the Groswater Bay terrane, in contrast to distinctly lower values for the Lake Melville and Hawke River terranes. M. Arima has completed a detailed study of osumilite-sapphirine occurrences marginal to a gabbronorite intrusion. Osumilite is a rare cordierite-like mineral; the locality (only the second known occurrence in Canada) was discovered during the course of mapping.

J.1.9.3. Central Labrador Granitoids (A. Kerr)

Objectives. This project was intended to provide a geological, petrochemical and geochronological framework for igneous suites in the Makkovik Province, and to evaluate their role in the geological and metallogenic evolution of the Central Mineral Belt. Geochemical and petrological studies of individual plutonic associations were aimed at definition and delineation of potential specialized granitoid rocks. Nd and Sr isotopic studies of selected samples were aimed at evaluating petrogenesis, and also investigating the nature of the lower crust in eastern Labrador.

Methods. This was not a mapping project in the strict sense of the term. Work in 1985 consisted of a large-scale, grid-based, lithogeochemical sampling program covering all intrusive rocks within the Kaipokok Bay–Big River area. Samples were collected at an average density of one per 5 km². During 1986, activities involved follow-up sampling and mapping of favourable zones, at an average density of one sample per 1 km², and extension of the regional program eastward into the Benedict Mountains. In 1987, follow-up work and mapping continued on a reduced scale. The large size and inaccessibility of the study area made field work heavily dependent on helicopter support. Major- and trace-element analyses were mostly performed at the Department of Mines and Energy laboratory. U–Pb zircon dating was conducted by T. Krogh and co-workers at the Royal Ontario Museum; Nd and Sr isotope geochemistry, and Rb-Sr geochronology, were conducted by the project geologist at Memorial University.

Results. Work has essentially confirmed previous bedrock mapping in the Benedict Mountains area. In the Kaipokok Bay–Big River area, several new regional units were defined, and previous groupings and correlations were revised substantially. A geological, petrological and geochronological framework has now been established, although some units remain undated.

It has been shown that the dominant intrusive assemblage in the eastern Central Mineral Belt is associated (broadly) with the ca. 1800 Ma Makkovikian orogeny. This includes both foliated (syntectonic) and massive (posttectonic) suites; some of the latter are probably as young as 1720 Ma, and represent the terminal phases of Makkovikian magmatism. These rocks are locally slightly peralkaline, and resemble 'A-type' or 'within-plate' granite suites. They are siliceous, potassic and enriched in Fe, Zr, REE and F.

'Labradorian' intrusive rocks, of ca. 1650 Ma age, are less abundant than previously thought. They comprise gabbro to syenite suites (derived from mafic parental magmas), and a variety of leucocratic granites. The latter do not show the 'A-type' affinities of the Makkovikian assemblage, and tend toward slightly peraluminous compositions showing depletion in Zr, REE and F. Mafic rocks resemble shoshonites or high-K calc-alkaline basalts.

Potential specialized granitoid suites occur in both major groupings, and are defined by major-element enrichment–depletion patterns, alternation features, and known mineral occurrences. A group of fluorine-enriched biotite granites (probably ca. 1720 Ma old) is the most widespread, and has potential for Pb, Zn, Mo, F (± Au, Ag, Sn) mineralization. Minor showings of these commodities are associated with some members of this suite. Small bodies of leucocratic granites of 1650 to 1630 Ma age contain disseminated Mo mineralization, and one stock is spatially associated with epigenetic veins containing Mo, Cu, Pb, Zn, F, U and Au.

Isotopic studies, particularly using Nd, demonstrate fundamental contrasts in magma source materials from west to east across the Makkovik Province. These variations probably reflect a fundamental boundary between Archean and Proterozoic lower crustal domains. There is no evidence of Archean crust east of the Kaipokok Bay–Big River area.

J.1.9.4 Western Grenville Project (G.A.G. Nunn)

Objectives. Prime objectives of the project were the regional mapping, tectonic synthesis and economic evaluation of NTS map areas 23A/SE, 23A/SW, 23A/NW and 23H/SW along with parts of 22P/NE, 22P/NW and 23B/SE. Mapping of these areas, and the follow-up work involved, will complete the basic regional study of the Grenville Province in western Labrador. Continuing work on NTS map areas 23A/NE and 23H/SE (mapped immediately prior to the start of this project) is an integral part of the program.

Methods. The area was scheduled for mapping in quadrangles of four 1:50,000-scale map areas. Irregular areas along the Labrador–Quebec border (22P/NE, 22P/NW and 23B/SE) were combined into their adjacent quadrangles in Labrador.

Each area was mapped in an approximately three-month-long summer field season with a mapping crew of two to five and a field-support crew of three to six. Total isolation of most of the region necessitated helicopter-mapping support and fixed-wing logistical support.

In addition, a special study of the boundary of the Lac Joseph allochthon, within the project area, was undertaken in the summer of 1987 by J.N. Connelly. This part of the project involved a field crew of two using water and road access and more limited helicopter support.

Results. Mapping is completed for all areas except 23A/NW and 23H/SW, although parts of these areas have been included in the study on the boundary of the Lac Joseph allochthon. Geochronological data obtained in the previous program indicated the presence of a new orogenic terrane, within the Grenville Province of central Labrador, of ca. 1710 to 1600 Ma, termed the Labrador orogen. Subsequent work has confirmed the extent of the Labrador orogen in the project area and extended it in other project areas throughout the northern part of the Grenville Province in Labrador.

The Labrador orogen comprises a unique association of high-grade, aluminous paragneiss, large gabbronorite and anorthositic complexes, and the relatively potassic, granitoid Trans-Labrador batholith with its gneissic equivalents and coeval cover sequences, all of which have isotopic signatures of 1650 ± 100 Ma. Peak development of the orogeny occurred between 1680 and 1640 Ma. and it has been named the Labradorian orogeny. The rocks of the Labrador orogen have been complicated as a result of variable metamorphism, deformation, intrusion and tectonic slicing by events associated with the Grenvillian cycle.

In addition to the normal studies required for a geological synthesis of an area, special programs include radiometric dating, P–T determinations and structural w[illegible]on terrane boundaries. Although the paragneiss has failed to show much economic potential to date, the anorthositic bodies are of interest for Fe and Ti mineralization, and the gabbronorite bodies have platinum-group-element potential.

J.1.9.5 South Coast–Kaegudeck (W.L. Dickson)

Objectives. The purpose of this project was to survey the 11P/10 (Cape La Hune) and 11P/11 (Ramea) NTS map areas, on the south coast of Newfoundland, and the 2D/3 (Mount Sylvester) and adjacent 1M/14 (Hungry Grove Pond) NTS map areas in southeastern Newfoundland.

This south-coast project was carried out in conjunction with R.F. Blackwood who was responsible for mapping the distinctive belt of Precambrian metamorphic rocks in the vicinity of Grey River.

Methods. A 1:50,000-scale mapping and regional lithogeochemical survey was carried out during 1984 on NTS map areas 11P/10 and 11P/11 (apart from the Grey River area) by a four-person geoscientific crew. The project also sponsored a graduate student and a junior assistant who carried out a more detailed mapping and geochemical survey of part of the François Granite (in map area 11P/10). Fieldwork was carried out by foot and boat traversing from helicopter-placed fly-camps.

The 2D/3 map area was surveyed during 1986 and 1M/14 was surveyed during 1987. Both areas were mapped by a two-person team at a 1:50,000 scale with emphasis on the sedimentary and volcanic rocks.

Geochemical analyses were carried out by the Department of Mines and Energy laboratory in St. John's, the Department of Earth Sciences at Memorial University, the graduate student sponsored by the project, and under contract with a commercial laboratory. Thin sections were made under contract with the Department of Earth Sciences. Radiometric dating was done under contract by the Royal Ontario Museum.

Results. Mapping of the 11P/10 and 11P/11 NTS map areas resulted in the definition of major plutonic units, outlining of internal contacts within granitic plutons, the discovery of extensive faulting and shear zones, and the relationship of the metasedimentary rocks to the granitoids, which could be derived in part from the metasedimentary rocks. Geochemical analyses indicate that the Burgeo Intrusive suite is composite and appears to be derived from two distinct sources. The François Granite is a composite ring complex in which the

granites are highly differentiated. Significant mineralization was not found but the François Granite has significant potential for granophile-element mineralization such as W, Sn, U and Th.

The 2D/3 (Mount Sylvester) map area contains sedimentary and volcanic rocks of the Baie d'Espoir Group, which are probably in unconformable contact with the psammitic Gander Group. The Baie d'Espoir Group is deformed into refolded recumbent folds. A series of southeast-dipping ultramafic slivers separate the North Steady Pond and St. Joseph's Cove formations of the Baie d'Espoir Group. Extensive alteration occurs in the Ordovician felsic volcanic rocks, which contain gold and antimony mineralization.

Due south of map area 2D/3, the 1M/14 (Hungry Grove Pond) map area contains a portion of the Baie d'Espoir Group that has been divided into two formations. The southeastern formation is bisected by a major fault (and associated ultramafic rocks) that parallels the formation and juxtaposes a weakly metamorphosed and cleaved sedimentary sequence with intensely deformed schistose felsic and mafic volcanic and semipelitic schists, which host gold and antimony mineralization. These schistose units are mainly in faulted contact with migmatites and schists that may in part correlate with the Gander Group. The Paleozoic granitoid rocks comprise a deformed complex intruded by massive plutons, which also intrude the Ordovician strata. Precambrian units lie to the south of the Hermitage Bay Fault, which separates the Paleozoic strata from dominantly late Precambrian strata. The Precambrian rocks form a shallow-marine(?) sedimentary and a subaerial volcanic formation, which is mainly in fault contact with a bimodal gabbro–granodiorite suite. Locally extensive gossans occur in the pelitic sedimentary rocks, but analyses for gold yielded only background values.

J.1.9.6 Cambro-Ordovician Carbonates (I. Knight)

Objectives. The purpose of the project was to complete regional 1:50,000-scale geological mapping of the Cambro-Ordovician carbonate terrane north of Daniel's Harbour.

Methods. Field work was undertaken by two- and five-man field parties that included a senior mapping assistant (1984), junior assistants and a bushman. Access to the mapping areas was mostly by highways, forest-access roads and boat, and the project utilized a few hours of helicopter support each year. Petrographic studies and geochemistry of rock units were carried out. The mapping and stratigraphic studies were supported by paleontological research conducted by D. Boyce.

Results. The mapping of the Cambro-Ordovician carbonate-shelf terrane on the Great Northern Peninsula north of Daniel's Harbour was completed by 1988. The work has resulted in the definition of a firm lithostratigraphy and an understanding of depositional environments.

Following the deposition of mixed siliciclastic and carbonate rocks of the Labrador Group on a low-to-high-energy ramp, subtidal and peritidal carbonate rocks of the Port au Port and St. George groups formed a long-lived platform. Subsequent Taconic tectonism affected the passive margin, causing faulting and uplift of the platform (St. George Unconformity) and late flexural subsidence. Limestone of the Table Head Group was then deposited as a narrow shelf along the margin of the foreland basin.

Further detailed analysis of the composition and correlation of small- and large-scale sequences that make up the passive margin may lead to further understanding of the evolution of the platform during the Early Paleozoic. Although syndepositional faulting and gentle folding occurred in the Middle Ordovician associated with early Taconic tectonism, the rocks were mainly deformed in the Acadian. A thrust stack in the east deforms mafic dykes that have an Ar–Ar age of approximately 410 Ma.

Base metals and industrial commodities have been delineated within their stratigraphic and geographic contexts. The main Zn mineralization occurs within the St. George Group, close to synsedimentary faults and sinkhole deposits beneath the St. George Unconformity. Minor mineralization is hosted by Cambrian dolostone. Mapping has also defined enormous reserves of industrial stone including high-quality limestone, dolomite and marble; the latter are now being actively explored and locally are in initial phases of production. Very common petroliferous odour and pyrobitumen in dolomitized carbonate of Ordovician age indicate a good potential for hydrocarbons in the subsurface of western Newfoundland.

J.1.9.7 South Coast–Avalon (S.J. O'Brien)

Objectives. The project has two independent components whose primary aims are completion of 1:50,000-scale mapping in the Hermitage Flexure area of the southern Newfoundland Appalachians, and initiation of systematic regional mapping in the Bonavista Bay area of the Avalon Zone.

Methods. Field work in the Hermitage Flexure was undertaken over a 3-month period in 1984 and a 4-week period in 1985. In 1984, mapping of NTS map area 12A/3W was completed. Traverses were initiated from five-man base camps at Burnt Pond canal and various fly-camps. Also in 1984, a four-man party utilizing helicopter-supported fly-camps completed mapping of NTS map area 11P/12, and undertook systematic lithogeochemical sampling of granites in that area.

Systematic 1:50,000-scale mapping of the northwest Avalon Zone, together with allied sedimentological, geochemical and geochronological studies, was initiated in 1986 in the east half of NTS map area 2C/12. Mapping of that part of NTS map area 2C/13 west of the Dover Fault was

completed in 1987. A brief field study in 1988 (with I. Knight) concentrated on regional correlation of subdivisions that were erected as a result of the previous field work. During 1987 and 1988, field work was carried out by a two-man party based in the communities of Eastport and St. Chad's. More detailed logging of specific sections was completed by I. Knight, in collaboration with the stratigraphic and related mapping studies. Geochronological support was provided by the Royal Ontario Museum.

Results. South Coast. This work had the following results: the subdivision of the Burgeo Intrusive suite into several structurally, chemically and petrographically distinct plutons, at least some of which are petrogenetically unrelated; the recognition of its Silurian age (geochronology carried out by the Royal Ontario Museum); the recognition of pre-Silurian gneiss enclaves within the Silurian batholiths; recognition of the distintive chemistry of the Devonian plutons relative to the Silurian magmas; and the discovery of the importance of pre-Silurian structures as controls of later magma emplacement. Further lithogeochemical sampling of the Burgeo Intrusive suite was undertaken in 1985. During the same season, reconnaissance mapping with the ultimate aim of producing a 1:250,000-scale map of IIP was completed. In 1988, a brief field study was undertaken in the western Hermitage Flexure; the main aim was to compile the geology of the region south of the Bay d'Est Fault. Major results of this and affiliated geochronological studies include the recognition of late Precambrian crust in the southern Hermitage flexure, discovery that the Hope Brook Mine is hosted by Precambrian rocks, the confirmation of a sub-Silurian unconformity, and the recognition of the thrust relationship between Precambrian and Silurian rocks throughout much of the region west of the Chetwynd Granite.

Avalon. The field work has shown that the late Precambrian Love Cove Group conformably underlies the Connecting Point Group, and that the latter lies unconformably beneath late Precambrian terrestrial clastic and volcanic rocks (Musgravetown Group). It has been shown that there are two chemically, lithologically and stratigraphically separate volcanic (and coeval plutonic) units in the region. One, which is 620 Ma, has a calcalkaline character, and has a potential for gold mineralization; the second, which is 570 Ma, is alkaline to peralkaline, and has significantly elevated values of REE's. The field work, in conjunction with U–Pb geochronology, has demonstrated that some deformational features of the sub-Musgravetown strata are Precambrian and genetically related to faults, which have been subsequently reactivated in the mid-Paleozoic. Finally, the Connecting Point Group, which is in excess of 4 km thick, is demonstrated to be the product of sedimentation adjacent to an active volcanic arc, whose remnants are found in the Love Cove Group. Its multi-stage basin evolution records initial pyroclastic-dominated basinal sedimentation, through submarine-fan deposition, into production of pelagic deposits. Widespread olistostrome deposition and synchronous mafic magmatism preceeded basin extension and deposition of extensive turbidites.

J.1.9.8 South Coast–Gander Zone (P.P. O'Neill; R.F. Blackwood)

Objectives. The purpose of the project was to complete the mapping at 1:50,000 scale of the Grey River enclave and the northeast portion of the Gander Zone. The principal goals of the project were definition of any significant mineralization, elucidation of the metamorphic history of the area and boundary relations of the northeast Gander Zone with the adjacent Dunnage and Avalon zones.

Methods. The project was initiated in 1984 (Blackwood) with the mapping of the Grey River enclave on the south coast; boat work was conducted out of Grey River. Mapping of the northeast part (O'Neill) was initiated in 1986 on the west half of the Weir's Pond map area. In 1987, the east half of the Weir's Pond area was mapped. In 1989 parts of the Gander Lake and Gambo areas were mapped. In each field season, the work was carried out by a two-man party. The east and west margins of the Weir's Pond map area were accessible from highways and old logging roads; the central part of the area was accessed from helicopter-shared fly-camps. Numerous ponds throughout the area allowed extensive use of a boat.

Results. South Coast. The Grey River enclave consists of felsic volcanic, metasedimentary and amphibolitic rocks that exhibit increasing metamorphism from north to south, culminating in migmatites. Large, pretectonic quartz veins and much smaller, posttectonic, wolframite-bearing quartz veins are distinctive features of the Grey River area.

Gander Zone. The three principal geological subdivisions of the Weir's Pond map area are the Gander River Complex (formerly the Gander River Ultrabasic Belt), the Davidsville Group and the Gander Group. Stratigraphic subdivision of the Davidsville Group resulted in the definition of the Weir's Pond, Hunt's Cove and The Outflow formations. Rocks of the Weir's Pond Formation only occur nonconformably overlying, or structurally imbricated with, igneous rocks of the Gander River Complex. The Weir's Pond Formation was probably associated with the complex from late Arenig times. Immobile-element chemistry of mafic and felsic rocks of the Gander River Complex suggest an island-arc affinity. Ultramafic rocks of the complex may form remnants of an ophiolitic substrate to this complex. Ultramafic and volcanic detritus in late Arenig sandstone of the Weir's Pond Formation imply exhumation and erosion of the complex during the Arenig.

Stratigraphic subdivision of the Gander Group resulted in the definition of the Jonathans Pond and Indian Bay Big Pond formations. The western boundary of the latter formation is interpreted to be in stratigraphic contact with the Jonathans Pond Formation. Fossiliferous boulders found only within the area of outcrop of the Indian Bay Big Pond Formation are late Arenig to early Llanvirn; this age is tentatively assigned to the formation.

The metamorphic character of the rocks in the Gander Zone does not demonstrate a simple eastward prograde metamorphism (as in previous reports). Instead, three types of metamorphism are defined: a low-pressure, high-temperature contact metamorphism associated with the post-tectonic Deadman's Bay Granite, a low-pressure, high-temperature 'regional-type' contact metamorphism associated with the Ocean Pond Granite, and a medium-pressure metamorphism characterized by kyanite. Ar–Ar ages on muscovite and biotite indicate that the low-pressure, high-temperature, regional metamorphism was early Devonian.

The recognition of intermediate subvolcanic intrusive rocks in the Indian Bay Big Pond Formation, and a gold assay of 2200 ppb from quartz veins in rocks of this formation, resulted in several mining companies staking claims; their work is ongoing.

J.1.9.9 Geochronological Support (S.P. Colman-Sadd; R.J. Wardle)

Objectives. This project was designed to assist mapping projects by determining the age of important rock units in the different field areas of Newfoundland and Labrador.

Methods. Two geochronological methods have been used in the dating of Newfoundland rocks. The largest portion of available funds has been spent on U–Pb dates, determined under contract with the Royal Ontario Museum (where the laboratory of Dr. Thomas Krogh is the world leader in this technique). A small amount of funding was set aside for Ar–Ar dating, which was done by Dr. D. Lux of the University of Maine.

Labrador rocks were dated using the U–Pb technqiue at the Royal Ontario Museum. This technology makes it possible to date Precambrian rocks within a precision of ± 1 million years, allowing for the reconstruction of the Precambrian stratigraphic record.

Results. Newfoundland. U–Pb dates have been reported by the Royal Ontario Museum to the Department of Mines and Energy in a series of annual reports. The annual production was:

1985-86: 17 analyses providing 3 regular dates, 1 upgraded date on a previously analyzed sample, and four single-grain dates on detritus in a sediment sample.

1986-87: 16 analyses providing 3 regular dates, and four single-crystal dates on detritus in a sediment sample.

1987-88: 19 analyses providing 5 regular dates.

1988-89: 12 analyses providing 3 regular dates.

Ar–Ar dates were done in 1987-88 (12) and in 1988-89 (6).

The principal results that have emanated from the U–Pb program in Newfoundland are as follows:

1. A revolution in the understanding of the geology of the south coast of the Island. Before the dating began, all stratified rocks in the Hermitage Flexure area were thought to be Ordovician. Dating showed that the La Poile Group in fact consists of Silurian and Precambrian sequences, and subsequent field work has been able to confirm the very localized presence of an unconformity. This is the first indication of Precambrian basement in the Dunnage Zone and is particularly important because the Precambrian rocks host the Hope Brook gold mine. The dating changes the ground rules for exploration for this type of deposit.

2. Recognition of Silurian orogeny in Newfoundland involving igneous intrusion and extrusion, and high-grade metamorphism.

3. Confirmation of stratigraphic information that the Avalon Zone Precambrian rocks contain two distinct volcanic episodes that are separated by unconformable relations and a substantial time interval.

4. Proof of the efficacy of detrital-zircon methods in correlating units (in the Gander Zone). The main part of this work still remains to be done before conclusive results can be produced, but work so far promises to yield an important new tool in terrane interpretation.

Ar–Ar dating has been used in two areas and the results are:

1. In the Gander area, metamorphic cooling took place in the Devonian and corresponds to igneous events. This work can be incorporated with U–Pb dating and metamorphic studies to produce a P–T history for the area.

2. Mafic dykes cutting Cambro-Ordovician platformal rocks of the Humber Zone are variably affected by thrusting. They yield Silurian and Devonian dates, indicating a significant Acadian event, as well as the well-known Taconian thrusting.

Labrador. U–Pb dates have been described in a series of contract reports as follows:

1986–10 dates; 1987–8 dates; 1988–21 dates; 1989–8 dates.

The principle results that have emanated from the U–Pb program in Labrador are as follows:

1) The most significant result has been the confirmation that most of the northern half of the Grenville Province (the only part that has been mapped in detail to date) in Labrador comprises crust formed in a major orogenic episode, ca. 1710 to 1630 Ma, termed the Labradorian Orogeny.

2) Post-Labradorian crustal additions that have been documented form the Pinware terrane of southeast Labrador, which was formed ca. 1440 Ma., and a major belt of syn- to post-Grenvillian granite of ca. 1000–950 Ma across southern Labrador.

3) The ages of the economically important Aillik and Bruce River groups of the Central Mineral Belt have been established as 1860 and 1640 Ma respectively. The age for the Bruce River Group indicates a genetic association with the Trans-Labrador batholith.

4) Generation of high-level mineralized plutons in the eastern Makkovik Province occurred ca. 1800 Ma in association with late Makkovikian events, rather than in conjunction with Labradorian magmatism (ca. 1650 Ma) as previously thought.

5) Dates from the Churchill Province indicate that a substantial area in the interior of the province is underlain by Archean rather than Lower Proterozoic rocks as previously thought. These rocks have the characteristics of greenstone belts and suggest a higher mineral potential for this area than previously thought.

Proterozoic deformation appears to have begun ca. 1907 Ma on the eastern margin of the Province and terminated ca. 1811 Ma, following intrusion of the De Pas batholith.

J.1.9.10 Granite Metallogeny, Labrador (R.R. Miller)

Objectives. The purpose of the project was to document the geology, geochemistry and petrography of rare-metal mineral deposits in peralkaline felsic rocks in Labrador, with emphasis on the Strange Lake deposit and the showings in the Letitia Lake area. The compiled data will be used to develop ore-deposit models for rare-metal mineralization, which will aid the exploration for, and evaluation of, rare-metal deposits.

Methods. The project was split into two portions: the Strange Lake deposit and associated granite; and the Nb–Be ± Y mineralization in the Shallow Lake–Letitia Lake area. The Strange Lake portion of the project consisted of: a) compilation and interpretation of diamond-drill hole and other exploration–development data from the deposit, b) logging of drill core from the deposit, c) outcrop mapping of the peralkaline granite (1:10,000 scale), d) preparation of a 1:2,000-scale map of the Strange Lake deposit, e) representative sampling of outcrops and mineralized boulders, f) chemical and petrographic analysis of samples, and g) data interpretation, manipulation and analysis. Project work in the Letitia Lake area consisted of: a) preparation of 1:580- and 1:2,320-scale outcrop maps in the area, b) preparation of a 1:10,000-scale map of the Two-Tom Lake area, c) preparation of a compilation map of the geology of the area underlain by the Letitia Lake Group, d) representative sampling of outcrops and mineralized boulders, e) chemical and petrographic analysis of samples, and f) data interpretation, manipulation and analysis.

The field work was carried out by a field party of two. The chemical analyses were performed in the Department of Mines and Energy laboratory and by outside contractors.

Results. The Strange Lake portion of the project resulted in a significant contribution to the knowledge of the formation of late-stage pegmatite–aplite-hosted rare-metal mineralization in peralkaline granitoids. The availability of the core from numerous drillholes and the presence of a bulk-sample trench within the deposit provided data to determine the structure, chemistry, petrography and history of the mineralization. Interpretation of these data suggests that the mineralization is derived from the associated late-stage, highly evolved, peralkaline granite by a complicated process involving thermal–gravitational-assisted chemical differentiation and crystal fractionation during the formation of a volatile-enriched fluid phase in a crystallizing magma. Data were collected from the host peralkaline granite to determine the petrology of this incompatible-enriched host rock. The data from the Strange Lake granite, and associated data from Quaternary and geochemical studies in the surrounding region, provide valuable information to exploration teams searching for similar rare-metal deposits.

The data collected from the Letitia Lake area indicate that the Nb–Be ± Y deposits are hosted by peralkaline trachytic flows or tuffs spatially associated with peralkaline quartz syenite subvolcanic stocks. Re-compilation of the geology of the region based on this data and new field work indicates that there is high potential for the discovery of new Nb–Be ± Y deposits. The associated undersaturated peralkaline rocks and peralkaline granites also contain high background values of rare metals such as Zr, Y and REE, and therefore, are good exploration targets for these elements.

Study of rare-metal mineralization in Strange Lake, Letitia Lake and other areas in Labrador resulted in an exploration model of the geological settings and styles of rare-metal mineralization in peralkaline felsic rocks. This model has been applied to both Labrador and insular Newfoundland to identify new targets for rare-metal exploration; several excellent targets have been outlined.

J.1.9.11 Volcanogenic Sulphide Metallogeny, Victoria Lake (B.F. Kean; D.T.W. Evans)

Objectives. Metallogenic studies of the Victoria Lake Group were initiated to document the geology and tectonic setting of volcanogenic massive sulphide and epigenic gold mineralization. Such a study would aid in the understanding of the geology of the Dunnage Zone and facilitate the development of mineralization models, applicable on the regional scale, that would benefit the mineral-exploration industry.

Methods. A program consisting of detailed mapping, deposit-level studies, geochemical and regional gold sampling, age dating, and regional linear (structural) studies was undertaken. Field work was initiated in 1984 with detailed mapping and geochemical sampling of the Tally Pond volcanics and a detailed examination of the Boundary deposit. During 1985, activities included detailed mapping, geochemical and regional sampling of alteration zones for gold mineralization, and detailed studies of the Tulks Hill, Tulks East and Jacks Pond deposits. In 1986, detailed mapping, limited geochemical and gold sampling and detailed studies were carried out on the Victoria Mine and Midas Pond prospects. The program included an M.Sc. study by D. Evans. Activities during 1987-1989 were primarily office and laboratory studies supplemented by limited field work on selected areas.

Results. Regional metallogenic studies of the Victoria Lake Group produced a number of significant contributions to the understanding the regional geology of the Dunnage Zone, with implications for mineral exploration in the area. Newly examined bedrock exposures resulted in major revisions to the geological maps of the area. Detailed geochemical studies of mafic volcanic rocks indicate that the Victoria Lake Group is probably a composite of volcanic terranes. This geochemical study has also proved useful as a guide in base-metal exploration.

Age dating of the volcanic rocks has indicated that the island-arc rocks of the Victoria Lake Group are considerably older than previously thought, with at least three different ages of volcanic rocks being identified.

Studies of the volcanogenic massive sulphide deposits of the Victoria Lake Group indicate that these deposits are strataform and are related to the host volcanic sequences. They exhibit classic features and textures associated with island-arc rocks elsewhere.

Documentation of all known gold mineralization has been undertaken, including a detailed study of the Midas Pond prospect by D. Evans as part of an M.Sc. thesis (MUN). This, in conjunction with a regional structural interpretation based on linears defined from gradiometer maps, colour infrared airphotos and C-SAR radar imagery, has led to the development of mineralization models that may prove applicable regionally.

Plate 4. *Gold-bearing quartz veins (Long Lake showing, Victoria Lake Group) intrude a granite plug.*

J.1.9.12 Granite Metallogeny–Newfoundland (J. Tuach; C.M. Saunders)

Objectives. The purpose of the project was to document the geology of mineral deposits in granitoid rocks in Newfoundland with emphasis on granite-hosted gold deposits in western and southwestern Newfoundland, W–Mo–Bi mineralization in granites in central Newfoundland, and Zr–Nb–Y–REE mineralization in peralkaline granites in the Avalon Zone.

Methods. The project geologist and geological assistants collected samples from mineralized or specialized granites in southwestern Newfoundland, the White Bay area and the Granite Lake area during the summers of 1984-1986. These samples and samples collected from the Cross Hills intrusive suite during the summer of 1983 were sent for thin sectioning and analysis for major and trace elements, including gold and other economically important granophile elements. Samples were also collected from various gold occurrences and sent for Au assay. A full-time senior assistant was hired in May 1987 to assist in geochemical compilation, petrographic studies and minor follow-up field work.

Support facilities included external laboratories for preparation of thin sections, neutron-activation analysis of Au and other metallic elements, and ICP-MS analysis of selected samples for rare-earth elements. The electron microprobe and scanning electron microscope at Memorial University of Newfoundland in St. John's were also utilized. Helicopter support was necessary for sample collection from some areas.

Results. Studies were focused on disparate areas and geochemically varied granites, and have shown that granitoid rocks in insular Newfoundland host a variety of mineralization of different styles and origin. Some mineralization is genetically related to the host granite and was produced as a result of the emplacement and crystallization of the host pluton. The nature of such mineralization is influenced by the geochemistry of the granite. The peralkaline Cross Hills intrusive suite, for example, hosts Zr–Y–Nb–REE mineralization, which occurs in sheeted aplite veins and in the matrix to tuffisite. The peralkalinity of the granite may be one controlling factor in the concentration of such elements. At Granite Lake, in central Newfoundland, wolframite, molybdenite and native bismuth are found in sheeted quartz, quartz-greisen and quartz–pegmatite veins over a 25-km² area. Mineralization occurs both within, and externally to, the Wolf Mountain Granite, a specialized, alkali, muscovite granite with which the mineralization is believed to be related.

Mineralization may also be unrelated to the granitoid host rock. In the White Bay area, for example, gold mineralization is hosted by altered late Proterozoic granitoids. However, the mineralization also extends into unconformably overlying Cambrian sedimentary rocks and may be Silurian or younger.

An ongoing compilation of gold occurrences was begun during the project. Studies have shown that there is a spatial and perhaps genetic association between many gold occurrences and structural lineaments throughout Newfoundland. Many of these lineaments are sites of upthrusting of altered ultramafic rocks, which may have served as a source for the gold. Upwelling mineralizing fluids may have been focused along such lineaments, which are commonly large-scale, deeply rooted structures that may have been active throughout much of the Paleozoic.

J.1.10 ANALYTICAL AND OTHER TECHNICAL SERVICES

Four of the projects sponsored under the subprogram are as follows: **J.1.10.1 Analytical Support (H. Wagenbauer); J.1.10.2 Computer Support (H. Missan); J.1.10.3 Administrative Support (W. Ryder);** and **J.1.10.4 Cartography (K. Byrne).**

These projects provided support services, e.g., drafting, chemical analyses and financial administration, to the geoscientific research projects as required.

J.1.10.5 Lake-Sediment Analysis (P.H. Davenport)

Objectives. The purpose of the project was to delineate gold mineralization in Newfoundland by mapping the distribution of gold and related elements in lake sediment.

Methods. Organic lake-sediment samples were collected from all of insular Newfoundland between 1973 and 1982 under the two previous Mineral Development Agreements. These samples were analyzed for Cu, Pb, Zn, Co, Ni, Ag, Mo, F, U, Mn, Fe and organic content to assess the base-metal and uranium potential of Newfoundland, and to identify new mineral-exploration targets. Research and development work on the levels of gold and associated elements in lake sediment around known gold prospects led to a cost-effective method of determining the province's potential for gold mineralization and of identifying new exploration targets for gold. The approach used entails further chemical analysis of the existing samples by a non-destructive, multi-element technique. In addition to the data being of direct use in mineral exploration for gold and in regional metallogeny studies, the method provides comparable data on several other commodities, such as tungsten, antimony, arsenic and the rare-earth metals.

Results. As expected, the areas of the province that were known to contain economic or potentially economic gold mineralization are reflected by elevated values of gold and associated elements in lake sediment: the Mings Bight–Rambler area, the Betts Cove area, the Springdale Peninsula, the White Bay area, Little River–Kim Lake area, and the vicinity of the Hope Brook and Cape Ray deposits. New areas of gold mineralization were indicated by the lake-sediment data in the region between Gander and Gander Bay, and near Bishop's Falls, Bay d'Espoir, Facheux Bay, Grey River, and in southwestern Newfoundland. These newly identified gold-exploration targets have prompted the staking of several thousands of new mineral claims, and have significantly stimulated and directed grass-roots gold exploration. New areas of antimony, arsenic and tungsten mineralization have also been highlighted by the lake-sediment data, which will contribute to exploration for these commodities in the future. Samples from about half of the Island have been analyzed by this neutron-activation technique, and the project is continuing.

N.1.2 GEOLOGICAL INVESTIGATIONS

N.1.2.1 Paleontological Support (W.D. Boyce)

Objectives. The project provided paleontological support for Newfoundland mapping projects, particularly for the Cambro-Ordovician carbonate project (J.1.9.6). Independent studies were aimed at determining the biostratigraphy of the Cambro-Ordovician sedimentary sequences in western and central Newfoundland. It was hoped that additional fossil horizons in western and central Newfoundland would be discovered in order to provide better age control for geological models.

Methods. In western Newfoundland, detailed biostratigraphic sampling (for macrofossils and microfossils)

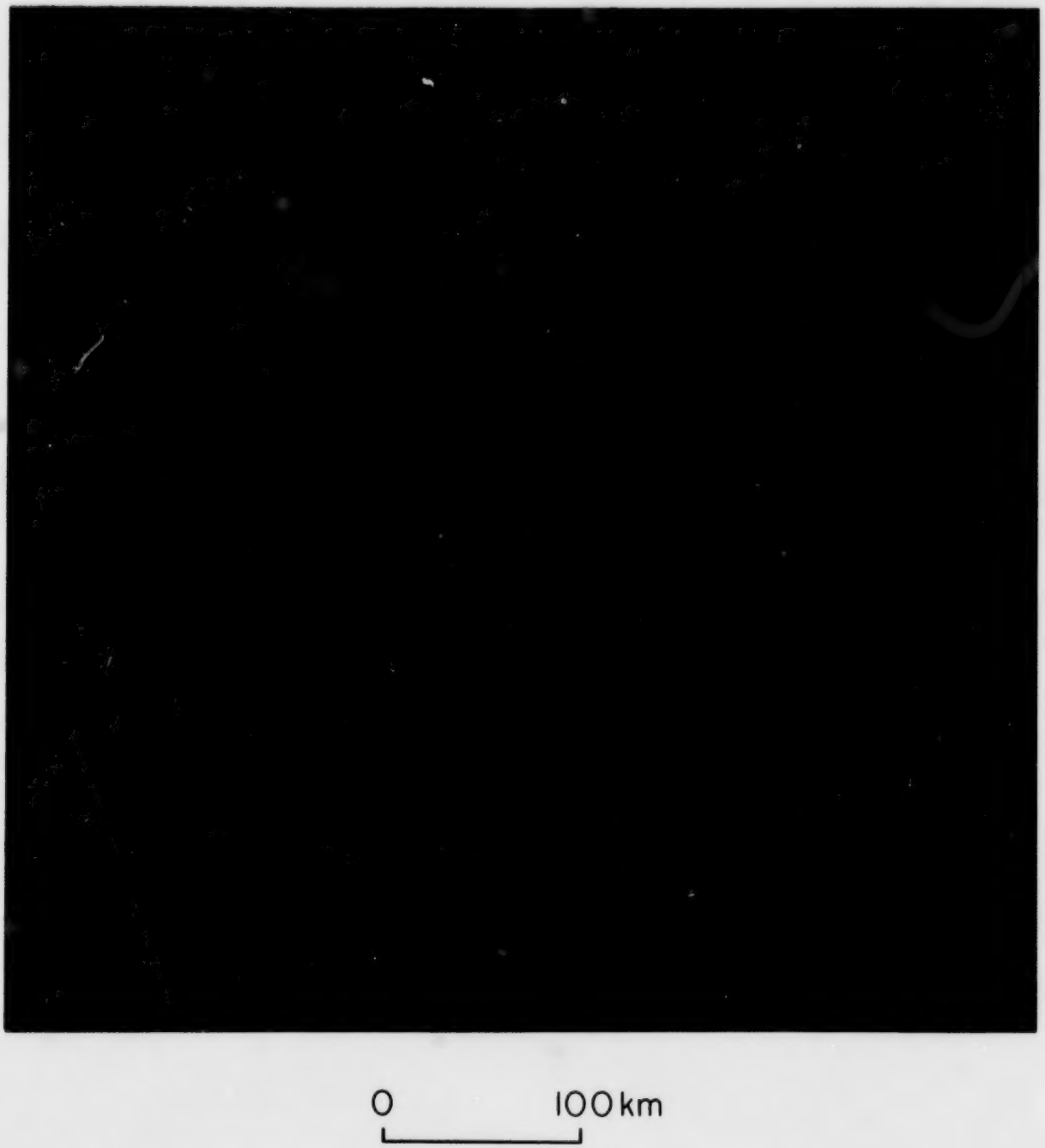


Figure 1. *The distribution of copper in lake sediment on the Island of Newfoundland portrayed as a shaded-relief image. Areas of high copper form the high-standing red, orange and yellow features, whereas the blue depressions are areas of low copper values. The copper surface is illuminated from the northwest, which emphasizes the northeast-southwest structural grain of Newfoundland.*

was conducted to complement the detailed lithostratigraphic investigations carried out simultaneously by I. Knight (Newfoundland Department of Mines and Energy). Co-operative biostratigraphic investigations were also carried out with P.L. Dean and J.R. Meyer (Newfoundland Department of Mines and Energy) and J.W. Botsford, N.P. James and S.H. Williams (Memorial University of Newfoundland).

In central Newfoundland, reconnaissance biostratigraphic sampling (for macrofossils and microfossils) was conducted in conjunction with S.P. Colman-Sadd, I. Knight, B.F. Kean, P. O'Neill and J. Tuach (Newfoundland Department of Mines and Energy) and R.B. Neuman (Smithsonian Institution). Much of this work required the use of boats or helicopters.

Results. The following are highlights of the paleontological-support project:

1) Previously unrecorded Early to Middle Cambrian trilobite faunas were discovered in Canada Bay and in Gros Morne National Park, requiring a major revision in the interpretation of the geological history of western Newfoundland.

2) Poorly known Early Ordovician graptolite faunas from the St. George Group carbonates were described in detail for the first time, aiding in the correlation of carbonate-shelf and carbonate-slope faunas. Several new graptolite horizons were discovered (graptolites are uncommon in carbonate rocks).

3) A preliminary Early Ordovician trilobite-based biostratigraphic zonation was proposed for the Boat Harbour and Catoche formations (St. George Group). This zonation may prove to be applicable along the Appalachian–Caledonide Orogen. Many areas were sampled in detail for the first time (i.e., Brent Islands, Burnt Island, Schooner Island) and have yet to be written up. As a consequence of this study, many new trilobite genera and species were described. Extensive conodont sampling was done also.

4) Previously unrecorded Middle Cambrian to Early Ordovician trilobite and brachiopod faunas were collected from the Cooks Brook Formation of the Humber Arm Allochthon.

5) Previously unknown Late Tremadoc trilobite and brachiopod faunas of Acado-Baltic type were collected from graptolite beds in the Cow Head Group of the Humber Arm Allochthon.

6) Previously unknown Early Mississippian vascular plants and (probable freshwater, lacustrine) paleoniscid fish were collected from the Snakes Bight Formation of the Anguille Group.

7) Previously unknown Late Arenig–Early Llanvirn and Late Llanvirn–Early Llandeilo trilobite and brachiopod localities were discovered from widespread areas on both sides of the Reach Fault. The trilobite faunas conclusively disproved the long-held hypothesis that the Reach Fault is the ancient Iapetus Ocean suture.

N.1.4 GEOPHYSICS

N.1.4.1 Geophysical Support (G.J. Kilfoil)

Objectives. The purpose of the project was to review regional geophysical coverage of the province, and to encourage and focus mineral exploration by planning and implementing geophysical surveys as follow-up in areas of high economic potential. It was also designed to assist geological mapping in areas of poor exposure, and provide some subsurface interpretation.

Methods. Several regional geophysical surveys were completed for areas within the province by the Geological Survey of Canada. High-resolution aeromagnetic gradiometer surveys, flown in three phases from 1985 to 1987, now cover much of the Central Volcanic Belt of insular Newfoundland, in parts of NTS areas 2E, 12A and 12H. Flown with auxiliary VLF-EM data, these surveys have proven successful in their design objective: to stimulate exploration and to evaluate the gold and base-metal potential that exists in these regions.

A large portion of central and western Newfoundland was surveyed between 1984 and 1987 by airborne gamma-ray spectrometric and associated magnetic and VLF-EM methods. A principal objective of this survey was to characterize the underlying rock types by their U–Th–K signatures, and thereby to enhance mapping in the principally intrusive terranes covered by these surveys.

Magnetic and VLF-EM ground surveys were established during summer field seasons as follow-up of anomalous features present in the regional surveys. In combination with physical properties of rock samples collected, field data were subsequently processed and modelled to develop a more detailed depiction of structural complexity than is discernable from aircraft altitudes.

In addition, support is provided to project geologists on a continuous basis by interpreting features that occur in the regional geophysical datasets, which may unravel structural and lithological complexity that is not readily apparent through surface mapping.

Results. During the last five years, emphasis has been placed on acquiring geophysical data in digital form and setting up the processing stream with the necessary hardware and software to speed its analysis. Much effort was expended

in organizing geophysical databases and establishing software links amongst hardware devices and software packages in order to expedite the interpretation of large datasets and their assimilation with other data types. Gridded datasets have been routinely generated that allow structural lineations related to mineralization to be systematically chosen through application of digital filters.

Detailed magnetic and VLF-EM traverses were established on the Port au Port Peninsula, Buchans, at Snowshoe Pond, Burgeo area and throughout a belt of ultrabasic rocks that extends from north of Gander to Bay d'Espoir. Field data from these surveys have been modelled and interpreted to complement the Department's mapping objectives in these regions.

The regional aeromagnetic dataset is presently being processed and filtered to remove inter- and intra-survey errors so that a large-gridded aeromagnetic database may be constructed for a contiguous area, such as the whole of insular Newfoundland. The corrected aeromagnetic data grid that results will not only allow linear features to be accurately and systematically chosen but will provide geoscientists ready access to the available potential-field data and thus enhance interpretation of specific study areas, irrespective of scale or location.

N.1.5 OVERBURDEN STUDIES

N.1.5.1 Quaternary Mapping– N.C.1.5.1 Labrador (M.J. Batterson)

Objectives. The purpose of the project was initially to complete 1:50,000-scale Quaternary mapping over selected areas of Labrador, starting with the Strange Lake area. Subsequent mapping focused on the Central Mineral Belt, in areas of ongoing or potential mineral-exploration activity. In particular, areas of thicker drift cover were investigated to provide base-line data on glacial history and sediment types for use in exploration programs.

Methods. Although the geographic area changed, individual projects adopted a similar strategy with similar support facilities; a crew of five was employed. Work was largely helicopter supported, although detailed work was undertaken on foot traverses. Mapping used a roughly 2- by 2-km sampling grid. At each site, a description of the geomorphology of the area was made, ice-flow directional indicators on bedrock were recorded, a test pit dug and sediment described and sampled. Commonly, surface pebbles were examined for presence of selected indicator rock types. These rock types have a distinct visual character and a known discrete source area, and were used to determine the distance and direction of glacial transport. Samples were analyzed for geochemistry and grain size in the Department of Mines and Energy laboratory.

Results. Strange Lake (NTS map areas 14D/5 and 24A/8). This area is the site of IOCC's Y–Zr–Nb–Be–REE deposit. Dispersal models developed here should provide a basis for examination of dispersal in other areas where the source of geochemical anomalies or mineralized float is unknown.

Plate 5. *A northward-looking view of a 30-m-high esker ridge within an outwash paleochannel along the southern shore of Strange Lake. The first mineralized clast associated with the Strange Lake deposit was found in this area.*

Elements related to the Strange Lake deposit (Be, Ce, La, Nb, Pb, Rb, Th, U, Y, Zr) commonly showed a ribbon-shaped dispersal train that extended at least 40 km down-ice of the deposit, having an orientation consistent with the direction of late Wisconsinan ice in the area. Within the geochemical dispersal train, anomalously high areas occur, which are commonly coincident with crag-and-tail hills. These anomalies likely result from the interception of deposit-related material by topographic highs that extended into englacial-debris layers or material carried high in the basal-debris load. In this way, anomalous geochemical values can be found far removed from their source. Clast dispersal from the Strange Lake deposit has a similar pattern to the geochemistry.

Letitia Lake (NTS map areas 13L/1 and 13L/8). This area contains a significant beryllium deposit (Mann #1 deposit) as well as several small yttrium and beryllium showings. A number of copper showings occur in the Seal Lake group. Two-Tom Lake (east of Letitia Lake) is an area of potential beryllium and REE mineralization.

Regional mapping showed that three regionally significant ice-flow events had affected the map areas, although it is unclear whether or not they all relate to late Wisconsinan ice. The last major flow event was east-northeastward and earlier ones were northeastward and east-southeastward respectively. Dispersal patterns from till geochemistry data and clast distribution relate to the last

major flow event, and transport is predominantly of short distance, although evidence of longer transport exists. The Two-Tom Lake project highlighted a zone of mineralization associated with syenite gneiss and at least two well-defined boulder trains. This work led to the staking of the area in 1985. The biogeochemical component of the project was largely unsuccessful in defining patterns of dispersal in the area.

Melody Lake/Moran Lake areas (NTS map areas 13K/7, 13K/9, 13K/10 and 13J/12). Three distinct terrain types were identified in these areas:

1) Below about 125 m asl, in the Kaipokok and Kanairiktok river valleys, marine sediments dominate. Shell fragments dated at about 7600 years BP were found in sediment beneath a large glaciomarine delta to the east of Moran Lake.

2) Between about 125 m and 300 m asl, boulder-covered glacigenic sediments occur, particularly in the Melody Lake area. Cross-valley moraines are common in this area, and eskers occur in most valleys.

3) Above 300 m asl, barren uplands are common and surficial sediment is generally thin and discontinuous.

The ice-flow history bears some relationship to the terrain differences. The upland areas are dominated by a northeastward-flow direction, although earlier flows are noted. The intermediate areas also show evidence of the northeastward flow but commonly show evidence of a more recent flow event. This suggests that within the same geographic areas several flow directions exist. The variation in flow direction as a function of elevation is found in both the Moran Lake and Melody Lake areas. The use of indicator rock types demonstrated that clast dispersal is consistent with the most recent glacial-flow events.

N.1.6 SAND AND GRAVEL

N.1.6.1 Aggregate-Resource Assessment (M.J. Ricketts)

Objectives. The purpose of the project was to carry out detailed and reconnaissance type surveys to identify potential aggregate sources that have specifications suitable for four distinct undertakings. The first was to assess the aggregate-resource inventory along possible transportation routes from Strange Lake, Labrador, to the Atlantic Coast. The second was to locate a sand deposit in western Newfoundland having a high-silica content and low percentages of alumina, magnesium and alkalis for use in the cement industry. The third was to identify deposits of granular aggregate material for potential export markets. The fourth was to carry out detailed aggregate mapping in evaluating deposits for use in the construction of offshore oil-production platforms.

Methods. The Strange Lake transportation-route study was completed by a two-man field crew during a two-month field season in 1984. The project was largely helicopter supported. The silica-rich sands study was carried out during a 1.5-month field season in 1986 with a two-man crew in conjunction with the North Star Cement Company of Corner Brook. The aggregates-for-export study was completed by a two-man field crew during a three-month field season in 1987. The study focused on the area in the vicinity of the Domtar Gypsum Mine on NTS map areas 12B/7 and 12B/8, because of the known presence of aggregate and the proximity of shipping and handling facilities. The detailed granular-mapping project for the offshore-platform construction was undertaken by a two-man crew in a two-month field season in 1985. The project was designed to map the aggregate potential in the coastal area of the proposed construction site.

All samples collected were, where possible, free of plant debris and topsoil, and were collected from natural exposures such as stream cuts, coastal sections and gullied areas. Where natural exposures were not present, samples were collected from hand-dug pits that extended into the C horizon (usually greater than 2 m in depth).

Results. Transportation Routes. Two routes originating at the Quebec–Labrador border near the Strange Lake deposit and extending in an easterly direction toward the Labrador coast were studied. The most favourable route follows an easterly direction along a glaciofluvial outwash system. A plateau section has large aggregate deposits and a well-developed esker ridge that should provide abundant construction material and a suitable route. The esker ridge connects with a well-defined valley containing abundant glaciofluvial outwash deposits, composed largely of kame deposits reaching heights up to 100 m.

Silica-Rich Sands. Thirty-seven sand and gravel deposits were sampled. Twelve deposits yielded suitable or marginally acceptable geochemical results. Some of these deposits have a coarse gravel content and thus require screening. Long-distance transportation may also be a negative factor for some of the deposits, and others may not be utilized because of proximity to residential areas. Despite these limitations, there are three potential deposits within the study area suitable to meet the requirements of the cement industry in Newfoundland for the foreseeable future.

Aggregates for Export. Twenty-six aggregate zones were mapped, many of which are small and cannot support a large mining operation. The added expense of constructing roads to more distant areas would make the project less profitable. Particle-size analyses indicate a high sand content in many zones, usually greater than 70 percent. Petrographic characteristics were generally within the range required for use in high-quality aggregate.

Plate 6. *A 12-m-high gravel face is exposed where the shoreline cuts a glaciofluvial outwash deposit on Woody Island, Placentia Bay.*

Oil-Production Platforms. Ten deposits were sampled, having individual estimated volumes that range from 16,000 m^3 to 8,000,000 m^3. Many other deposits are too small and/or have poor aggregate qualities. The most suitable deposit, located near Swift Current in Placentia Bay, is also the largest. It has good petrographic qualities, low silt/clay content and is relatively easily accessible by barge.

N.1.7 SUPPORT SERVICES

Three projects were sponsored under the subprogram as follows: **N.1.7.1 Analytical Support (H. Wagenbauer); N.1.7.2 Computer Support (H. Missan); N.1.7.3 Cartographic Support (K. Byrne).** These projects provided support services to the geoscientific research projects as required.

N.C.1.3 REGIONAL GEOCHEMISTRY

N.C.1.3.1 Follow-up of Regional Geochemical Anomalies (J.W. McConnell)

Objectives. The purpose of the project was to develop methods of using geochemistry to focus mineral exploration within areas of regional geochemical anomalies and to stimulate exploration activity, particularly in Labrador.

Methods. There were two thrusts to the project: granitoid-related mineralization (including Be, Y, Nb, Zr, W, REE and rare-metal deposits) and gold mineralization. The granitoid aspect applied successful sampling and analytical methods developed earlier in the area of the Strange Lake Nb–Be–REE deposit to other areas in Labrador that were identified from regional lake surveys. High-density lake-sediment and water sampling was done in 1985 in three areas of Labrador that were characterized by anomalous levels of F, U, Pb and Zn–elements commonly associated with the target mineralization. Samples were analyzed by the Department's inductively coupled plasma-emission spectrometer (ICP) and by neutron-activation analysis (NAA) for several elements not previously determined in lake sediment. A variety of statistical techniques was applied to the resulting data, some of which identified exploration targets using the multi-element aspect of the data.

The application of lake-sediment geochemistry to gold exploration was first evaluated in 1984 in areas of gold mineralization on the Island. This proved successful and was further tested in 1986 in other areas and then applied as a follow-up tool in western Labrador in 1986 by J. Butler and by J. McConnell in 1987. During the same period, orientation soil-surveys examined factors that control the dispersion of gold and associated elements in soil in eight areas of gold mineralization. Results of these soil studies were applied to some twenty areas in Labrador in 1987. An attempt was also made to evaluate the gold content of stream water as an exploration tool using the ICP mass-spectrometer at Memorial University of Newfoundland.

Results. Analyses of lake sediment from the granitoid survey in Labrador resulted in the identification of several new exploration targets for rare-earth and rare-metal-associated elements, including Be, Y, Nb, and Zr. Known peralkaline-related mineralization at Strange Lake and Letitia Lake was clearly reflected in the data. In particular, the work represents the first successful application of REE and Y geochemistry of lake sediment and water in mineral exploration and suggests that the areas of the province containing deposits of high-tech metals can be identified readily by re-analysis of the existing regional lake-sediment samples.

High-density lake-sediment sampling combined with analysis by NAA for gold and several other elements proved an effective method of identifying anomalous and prospective areas for gold mineralization. Antimony, and to a lesser extent As and Pb, were found to be effective pathfinder elements. The archived regional lake-sediment samples collected on the Island by the Department of Mines and Energy and those in Labrador collected by the Geological Survey of Canada are now being re-analyzed by this method. The release of these data has led to the staking of several hundred claims and has contributed to the discovery of many new gold occurrences on the Island.

Follow-up work in western Labrador has led to the discovery of several small gold occurrences and the staking of several claims in 1988 in areas that had never been previously prospected. Results of the orientation soil surveys included the recognition of the $< 63\ \mu m$ fraction as generally being the optimal fraction for analysis, the common association of Sb and As as pathfinder elements, the extent of dispersion trains associated with mineralization, and the

identification of gold grain size as being an important consideration when deciding whether to pan or directly analyze soil for gold. The attempt to use the gold geochemistry of stream water proved unsuccessful as the results were not reproducible. However, recent advances in analytical chemistry may still lead to it being effective as an exploration method.

2. MINING AND MINERALS TECHNOLOGY

N.2.1 DEPOSIT ASSESSMENT

N.2.1.1. Abandoned Mine Property Assessment (M.J. Collins)

Objectives. The objective of this program was to sample and analyze all tailings ponds generated from abandoned base-metal sulphide deposits in Newfoundland and to statistically screen for base, precious and strategic elements. The program sought to collect sufficient material from each tailings deposit to secure a representative analysis of its content and to identify, within volume constraints, element concentrations within the deposits.

Methods. Five tailings deposits, derived from volcanogenic sulphide ore bodies were sampled: Little Bay, Whalesback, Rambler, Gullbridge and Buchans. The tailings deposited within the Buchans Brook delta at Red Indian Lake were sampled using airphoto control; all others were controlled using measured, co-ordinated grids. A two-man crew collected 2,750 samples using several sampling techniques; all sample preparation was performed by the Department of Mines and Energy laboratory. Samples were analyzed for most transitional elements, actinides and lanthanides (approximately 50 elements) in multi-element packages using multi-method techniques. Analytical work was performed by the Department of Mines and Energy and out-of-province laboratories; all follow-up gold analyses were contracted to a local independent laboratory.

Results. Analyses of samples from the Rambler tailings deposit indicated elevated levels for gold, which were confirmed by more thorough and detailed sampling and analysis. The analytical data were included in a 'call for proposals' to explore and develop the Rambler Exempt Mineral Lands. This resulted in a detailed re-sampling for chemical analyses and metallurgical bench-scale studies for gold and base-metal recovery by a major Canadian mining company. Preliminary metallurgical results are encouraging.

Elevated gold values in portions of Buchans Tailings Pond No. 1 and high base-metal concentrations in the Buchans Brook delta deposit have resulted in inquires from the mineral industry.

N.2.1.2 Aggregate Production (F. Morrissey)

Objectives. The project was designed to evaluate the technical aspects of producing limestone aggregate from Aquathuna and anorthosite aggregate from Indian Head. Both localities are abandoned quarries in the Port au Port–Stephenville area of Newfoundland. Re-activation of these properties was the ultimate goal, based on economic studies that indicated potential U.S. markets.

Methods. This program involved sampling both quarries along their open faces; the material was then subjected to testing to determine its quality. A pre-feasibility study was also completed by an engineering consulting firm to determine capital and operating costs at various production levels, and to identify the major constraints to developing these properties. All of the data was then collated in one document and made available to all interested parties through an advertisement in national newspapers.

Results. As a result of the 'call for proposals', a Canadian mining company, Zeraldo Minerals of Aurora, Ontario, has been granted a one-year permit to explore for quarry materials on the Aquathuna site. Resource end-products and market studies will be conducted to meet special terms and conditions of the licence.

N.2.1.3 The Asbestos Institute (F. Morrissey)

Objectives. The purpose was to have Newfoundland become a full member in the Asbestos Institute and support the programs of the Institute in promoting the safe and effective use of asbestos.

Results. Newfoundland is now a member of the Asbestos Institute and its representative attends board meetings. The Provincial Government supports and participates in the various activities of the Asbestos Institute in an effort to enhance markets for Canadian asbestos and help ensure the continuation of asbestos mining and processing in Newfoundland.

3. ECONOMIC DEVELOPMENT STUDIES

N.3.1 INDUSTRIAL MINERAL COMMODITY AND INDUSTRY STUDIES

N.3.1.1 Asbestos Task Force (B. Hynes)

Objectives. The purpose of this project was the secondment of an officer of the Department of Mines and Energy to the Federal Department of Energy, Mines and Resources to work on matters related to the asbestos industry.

Results. The officer was involved with the development of Canada's submission to the American Environmental Protection Agency on its proposal to ban asbestos, and assisted in the preparation of information presented to the U.S. Occupational Safety and Health Administration relative to pending regulatory action by that body. The officer assisted in the development of information that was later presented to the International Labour Organization Convention and was used by various missions.

The project was seen as being very successful in that the number of actions taken by the various missions and interventions were successful. Also, there was a high degree of information and technology transfer, which was brought back to the Department of Mines and Energy.

N.3.1.2 Labradorite (B. Hynes)

Objectives. This project's main objective was to provide funding to the Labrador Inuit Development Corporation and thereby assist in the product development and marketing of labradorite and labradorite products.

Results. A private firm having the appropriate expertise was contracted by the Labrador Inuit Development Corporation to carry out this work. A report outlining a marketing strategy and other suggestions was presented. However, due to problems with the consultant, much of the work that had been identified as part of the contract was not completed.

N.3.1.3 Impact of Alternative Types of Regional Development Policy (B. Hynes)

Objectives. The purpose of this program was to do research to gain improved understanding of the economic impact of alternative types of regional-development policy on base-metal and gold exploration, development and production in Newfoundland.

Methods. Support for policy and planning was provided by developing a deposit-specific database, and an evaluation procedure for assessing the economics of base-metal and gold exploration, development and production in Newfoundland. This capacity will be applied to evaluation and comparison of the impact of alternative types of development policy including geological database development, direct financial assistance for mineral exploration, infrastructure support and new mine developments, corporate income and mining taxation incentives, assistance for operating mines based on temporary and permanent closure, and assistance to facilitate the supply of funds for mineral investment. The study drew on work already done by B.W. MacKenzie and M. Bilodeau at the Centre for Resource Studies at Queens University.

Results. The computer-based model that was used for assessing the effects of government policy on the economics of mineral supply was further expanded and used to facilitate the assessment of the Newfoundland situation. The report provides a great deal of detail on the above items, and will be used as a planning document for future programs and policies.

N.3.1.4 Economic Multipliers (B. Hynes)

Objectives. The purpose of this project was to develop empirical estimates of the relevant economic–financial multipliers specific to the mining industry. The various parameters of three multipliers were identified and measured on a regional basis.

Results. The multiplier aspect of the cost–benefit model has been written in computer language, and forms part of the larger, more complex cost–benefit model. This model will be used in the ongoing analysis of the industry and related policies.

N.3.1.5 Cost–Benefit Program (B. Hynes)

The cost–benefit model is written in computer-readable form. It assesses all relevant, direct and indirect costs and benefits to be derived from the mineral industry within the province. The effects are measured for Provincial, Federal and Municipal impact. The model will form part of the software available to the Department of Mines and Energy to assess new or expanded operations, and changes in Federal and Provincial policy.

N.3.1.6 Financial Cash-Flow Model (B. Hynes)

This project involved a further refinement of the cash-flow model and conversion to a computer-based system. This computer-based financial cash-flow model provides the Department with greatly increased capability to perform economic and financial analyses on existing mines and new projects. It also allows for the evaluation of new policy incentives, from Provincial, Federal and corporate perspectives.

N.3.1.7 Statistics Database (B. Hynes)

The objective of this program was to design and develop a computerized statistics database for the economic and financial information collected by the Department. The system was designed to capture and allow for manipulation of all major data items retained by the Department of Mines and Energy. The computerized database was designed to be used on microcomputers. The database has allowed for improved analytical reporting and forecasting functions within the Department.

N.3.2 MINERAL INDUSTRY ASSISTANCE PROGRAM (MIAP)–FEDERALLY FUNDED, NEWFOUNDLAND DELIVERED

N.3.2.1 MIAP Co-ordinator (B.F. Kean)

Objectives. The purpose of the Mineral Industry Assistance Program (MIAP) was to provide direct financial assistance to individuals and companies involved in the development of the mineral resources of Newfoundland and Labrador. MIAP provided this assistance by:

1) Providing part of the risk capital required by prospectors to finance the discovery of new mineral prospects, which might eventually lead to development. This funding was provided through the Prospectors Assistance Program (PAP). PAP contributed up to 100 percent of the eligible costs of the approved project to a maximum of $5,000 per project.
2) Providing financial assistance to individuals and companies to develop economically viable mineral resources. This funding was provided through the Feasibility/Demonstration Program (FDP) and the Industrial Minerals Infrastructure Program (IMIP). FDP provided grants to eligible companies or individuals to cover up to 50 percent or $50,000, whichever is less, of eligible costs of market studies, feasibility studies and demonstration projects related to new or proposed mineral developments. The IMIP provided grants to eligible companies or individuals to cover up to 50 percent or $100,000, whichever is less, of eligible costs of infrastructure for non-metallic mineral developments.

The role of the Program Co-ordinator was to manage, administer, supervise and monitor the program and all its sponsored projects in such a way that the aims and objectives of MIAP were achieved.

Methods. The Program Co-ordinator established the program guidelines, implemented, advertised and promoted the program, screened applicants, chaired the selection committee and recommended projects to the CNMDA Management Committee. The Co-ordinator also drew up project contracts, monitored the sponsored projects and recommended final payments.

Results. The program was successfully implemented and promoted. All elements of the program were over-subscribed; sponsored projects had a high rate of success. There has been positive feedback from the mineral-resource industry.

N.3.2.2 Prospectors Assistance Program (PAP)

Objectives. The purpose of this project was to encourage and increase new mineral discoveries and to promote the development of a local prospecting fraternity.

Methods. Risk capital was provided in the form of grants to eligible individuals to carry out independent mineral exploration on self-registered claims or Crown Land. The program contributed up to 100 percent of the eligible costs of approved projects to a maximum of $5,000 per project.

Proposals and applications were screened by a selection committee using eligibility and selection criteria set out in the guidelines agreed to by the CNMDA Management Committee and published in a information brochure.

Results. Twenty-eight applications for assistance were received. Twenty applicants, at a maximum of $5,000 each, were approved and advanced $1,000 each to purchase equipment, etc. Seven projects were in Labrador and thirteen on the Island. These projects covered most of the geological environments of the province, and had a wide geographic distribution. Minerals and commodities explored for included gold, base metals, labradorite, soapstone, dolomite, kyanite, garnet, mica and platinum. A number of new discoveries were made and approximately 800 claims were staked as a result of the program.

Two of the applicants had to terminate their programs for personal reasons. All of the other programs were completed. The mineral industry has strongly supported and encouraged the program.

N.3.2.3 Nut Cove Slate Quarry Access Road

Objectives. The purpose of this project was to construct a 5.5-km access road to the Nut Cove Slate Quarry on Random Island, Trinity Bay.

Methods. A $100,000 grant was awarded under the Industrial Minerals Infrastructure Program to construct an access road from Burgoynes Cove to Nut Cove. Construction was carried out by the quarry owner.

Results. The road was completed in December, 1988, and small-scale slate production started in the spring of 1989. The road has enhanced the economic viability of the quarry by reducing transportation costs and increasing the efficiency of logistics.

N.3.2.4 Granite Products Demonstration Project

Objectives. The purpose of this project was to produce demonstration products from local granite sources and to determine the feasibility of processing them locally.

Methods. A $50,000 grant was awarded under the Feasibility/Demonstration Program to A and G Industrial Products of Corner Brook, Newfoundland. They were to produce a variety of granite products for demonstration purposes and report on this project in the form of a case history.

Results. A and G Industrial Products established a temporary stone-cutting and polishing operation in Corner Brook. Stone was collected from a number of granite sites on the Island, in particular the Deadman's Bay Granite at Lumsden, and shipped to the Corner Brook facility. The stone is being used on levels one and two of the foyer in the new CERR Building, Memorial University of Newfoundland.

Because of this project, there has been a renewal of interest in the Deadman's Bay Granite as an ornamental stone.

N.3.2.5 Feasibility Study for an Underground Mining Operation at Baie Verte Mine

Objectives. The purpose of this project was to determine the feasibility of an underground asbestos mine at the existing Baie Verte Mine.

Methods. A $50,000 grant was awarded under the Feasibility/Demonstration Program to confirm ore reserves, devise a preliminary underground-mining design and to evaluate the economics of underground mining. The project was carried out by consultants under the supervision of Baie Verte Mine personnel.

Results. The study has been completed and results documented in a confidential report.

N.3.2.6 Feasibility/Demonstration Study on Croque Calcium Carbonate Deposits

Objectives. The purpose of this project was to conduct a feasibility and market study on the viability of producing calcium carbonate at Croque, Newfoundland.

Methods. A $50,000 grant was awarded to Aurion Minerals to conduct technical and market studies including transportation cost, cost of infrastructure and potential product uses and markets.

Results. The project has been completed and the results documented in a confidential report.

N.3.2.7 Conveyor Loading System at St. Lawrence Fluorspar

Objectives. The purpose of this project was to purchase and install a ship-loading conveyor system on the dock for St. Lawrence Fluorspar Ltd. This system would increase efficiency, reduce handling waste and costs and improve environmental control associated with the handling and loading of concentrate.

Methods. A $73,000 grant was awarded to St. Lawrence Fluorspar Ltd. to purchase and install the equipment.

Results. The necessary equipment has been purchased and delivered; installation has been temporarily delayed.

N.3.2.8 Labrador Inuit Development Corporation (LIDC) Craftshop

Objectives. The purpose of this project was to renovate and modify the LIDC labradorite and soapstone craftshop in Nain, Labrador. These renovations were undertaken to improve the work environment and to enable the Inuit craftspeople to better produce and promote their products.

Methods. A $7,900 grant was awarded to the LIDC to renovate the building, including a lapidary shop, silversmithing area and a carving and display area. The project was carried out by contractors under the supervision of the LIDC.

Results. Renovations and modifications have been completed.

4. PUBLIC INFORMATION, EVALUATION, ADMINISTRATION

N.4.1 PUBLIC INFORMATION

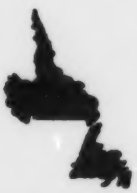
N.4.1.1 Public Information (R.F. Blackwood)

Objectives. The purpose of this project was to carry out public-information activities to make the public and the mineral industry more aware of the programs and results of the Canada-Newfoundland Mineral Development Agreement, 1984-1989. The emphasis for the general public was to raise the level of understanding of the province's mineral industry and the efforts under the CNMDA to foster an expansion of this sector. Activities directed toward the mineral industry were primarily to promote mineral exploration and development in the province, and facilitate the dissemination of data and geoscientific information generated by CNMDA activities.

Methods. A variety of promotional activities was employed in promoting the CNMDA and Newfoundland's mineral-resource sector. These were: the CNMDA Newsletter; articles and advertisements in a number of local, national and international publications; geoscientific exhibits (usually six to ten each year) at local, national and international meetings dealing with mining and mineral exploration; presentations to elementary and high schools for career days; and general presentations on geology and mining activity.

Results. Interest in the project displays at trade shows and conferences was very high; exploration activity in the province during the CNMDA set record levels, and as a result, delegates at the meetings made a point of visiting the display to gain more information on the mineral potential of Newfoundland and Labrador. Some of the new companies currently exploring in the province had their first exposure to Newfoundland's mineral potential via the CNMDA display. Also, significant results achieved by CNMDA-sponsored projects were released to the press through the respective offices of the Federal and Provincial ministers, and through the CNMDA Newsletter.

A video/slide show entitled Mining in Newfoundland and Labrador was produced, a copy of which was given to the Department of Education. The show is listed in their catalogue of video-instructional materials and is available to all schools in the province.



N.4.1.2 Geoscientific Information Services (C. Patey)

Objectives. Through GEOSCAN, a national bibliographic database describing geoscientific documents, the project's objectives were to provide printed indexes and online searches to the geoscientific files describing the province.

Methods. A geologist and a data-entry operator assisted the GEOSCAN project geologist in: indexing and adding bibliographic records for new assessment files; modifying converted records beginning with assessment-file records; and improving documentation for the project, including an indexing manual, coding sheets, print formats and authority files.

Results. The indexes and online searches provided an important tool for industry and government geologists researching a particular area, geological feature or commodity within the province. An NTS Index to 272 assessment files was published and approximately 600 more have been indexed for publication.

FEDERAL PROJECTS

1. GEOSCIENCE

C.1.1 MINERAL-DEPOSIT STUDIES

C.1.1.1 Metallogeny, Central Mineral Belt (T.C. Birkett)

Objectives. The purpose of the project was to conduct a regional metallogenic study of the Central Mineral Belt (CMB) in Labrador based upon industry and Newfoundland Department of Mines and Energy work, and supplemented by field studies. This work included detailed stratigraphic studies, geochemistry, geochronology and mineral-deposit studies.

Methods. a) D.H.C. Wilton and his colleagues (T. Brace, C.S. MacDougall, L.M. MacKenzie, J.W. North and C. Pumphrey), through a contract with Memorial University of Newfoundland, initiated field mapping, and subsequent petrology and geochemistry, on various parts of the Central

Mineral Belt during 1985 and continued working until the 1988 field season. b) During 1985-86, C. Payette and R.F. Martin (both of McGill University) completed a study on the composition of glass inclusions in quartz phenocryts of the Upper Aillik Group rhyolites. c) During the 1986 field season, S.S. Gandhi (Geological Survey of Canada) collected samples in the Makkovik area for subsequent U–Pb radiometric age dating. d) In 1987-88, S.S. Gandhi and R.I. Thorpe (GSC) compiled lead isotopic analyses for 36 galenas from selected base-metal and uranium occurrences in Aphebian and Helikian supracrustal sequences of the CMB.

Results. a) The widely varied mineral occurrences in the Central Mineral Belt appear to reflect the tectonic (depositional, magmatic and deformation) regimes present at the time of their development.

Plate 7. *Open folding of interbedded grey psammite and phyllitic schist of the Lower Aillik Group, Kaipokok Bay.*

The oldest mineralization in the Central Mineral Belt occurs in the Archean Florence Lake Group, wherein volcanic rocks host minor, probably syngenetic sulphides. However, the highly altered PGE-bearing syngenetic nickeliferous sulphide horizons in komatiites, which are correlative with a series of ultramafic bodies intrusive into the Florence Lake Group, are of much greater significance (such as the Baikie Showing).

Mineralization next appeared ca. 2000 Ma as syngenetic massive sulphide horizons developed within the sedimentary sequences of the Moran Lake (Warren Creek Formation) and Lower Aillik groups.

Minor U deposition occurred in the Michelin Zone of the Upper Aillik Group through synvolcanic leaching of the host felsic volcanic rocks shortly after their eruption at 1855 Ma. The broad period of 1800 to 1650 Ma was a time of extensive metamorphism, melting (migmatization), and granitoid intrusion. During this time, U mineralization was deposited in the Lower Aillik and Upper Aillik groups and the Kanairiktok Intrusive Suite (Mo–W–Cu at Round Pond; Mo–U–Cu–Pb–Zn at Burnt Lake).

The next definable mineralizing period was ca. 1327 Ma when syngenetic massive sulphide occurrences were developed within rhyolites of the Letitia Lake Group. REE–Be mineralization was also formed around the same time as pegmatoidal products of the Red Wine Intrusive Suite peralkaline magmatism.

The most extensive period of mineralization occurred during the Grenville orogeny. The regional-scale deformation produced fault–fracture systems that provided pathways for hydrothermal-fluid flow and also the heat to derive and drive the fluids. The Cu-vein systems developed in the Seal Lake and Bruce River Groups, and possibly the epigenetic sulphide-bearing shear zones within the Letitia Lake Group are products of this orogeny.

The final mineralizing episode is apparently related to the early Paleozoic lamprophyric magmatic event in the Makkovik Zone and is represented by the U occurrence at Showing No. 1 by Shoal Lake. The lamprophyric activity reflects the initiation of the rifting that formed the Iapetus Ocean in what is now the Appalachian belt.

b) Based on the composition of terrestrial glass inclusions and trapped microphenocryts, Payette and Martin discovered that the Upper Aillik rhyolites had a mildly peralkaline bulk composition prior to the intense metasomatic events associated with the later uranium mineralization.

c) U–Pb zircon/titanite dating (done at the Royal Ontario Museum) of two granitic intrusions have defined two episodes in the Makkovik orogeny, namely the 1802 $^{+19}_{-7}$ Ma Makkovikian and the 1910 ± 10 Ma Iggiuk events. Dating of zircons from a peralkaline, silica-saturated granitic older phase of the Red Wine alkaline complex (the 'Arc Lake gneiss') gave a 1337 $^{+10}_{-7}$ Ma age.

d) Gandhi and Thorpe's Stacey-Kramers model age of 2120 Ma for leads from the Cecil Lake occurrence is thought to represent the true age of mineralization. However, a model age of 2213 to 2044 Ma for the Sunil U–Mo Showing, Ford's Bight and Big Bight base-metal showings is deemed to be too old and implies the presence of a lower crustal lead component in the galenas. The 1858 to 1558 Ma model ages for the Moran Lake Group base-metal occurrences suggest that these leads were derived from host rocks and not from a lower crustal source.

C.1.1.2 Resource Assessment of Western Labrador (T.C. Birkett)

Objectives. The overall objective was to conduct a regional metallogenic study of western Labrador in order to identify and describe metallogenic domains and deposit-type environments, and thus stimulate exploration. The project also compiled data from the literature, Newfoundland Department of Mines and Energy files, and company reports; field work

was carried out in selected areas. Work was carried out by contractors and some by T.C. Birkett.

Methods. This project consisted of several subprojects. Geochemical studies on iron formations and the Doublet Sill were carried out under contract to B.J. Fryer of Memorial University. Detailed mapping was carried out by T.C. Birkett on the Fleming Chert Breccia. Birkett also compiled existing information on all known non-ferrous mineral occurrences of the Labrador Trough in the Dyke Lake–Astray Lake–Martin Lake area, and carried out systematic mapping and sampling of these occurrences. M.Sc. theses by J.M. Findlay and D. Watanabe, both of the University of Ottawa, were supported by the project; these studies investigated the mineral potential of gabbroic and ultramafic rocks in the Howse Lake (Findlay) and Dyke Lake–Astray Lake (Watanabe) areas by conducting field work and laboratory studies. Finally, a Ph.D. thesis was supported at Memorial University (J.A.M. Van Gool) to map the Grenville Front thrust belt in the vicinity of Wabush–Labrador City.

Results. The work by B.J. Fryer found evidence of contemporaneous enrichment of elements characteristic of alkaline magmatism in iron formations and associated shales north of the Schefferville area. Hydrothermal input into the iron-formation basin can be linked to the alkaline volcanic centres to the south in the Dyke–Astray lakes region, but is distinctive from primary magmatic element variations. In particular Nb, and to a lesser extent Zr, is strongly enriched relative to Y and the REE in enriched Attikamagen shales and basal iron-formation units. Pt and Pd are enriched in sulphide bands associated with this hydrothermal input on Dolly Ridge (both approximately 10 ppb or 10 x background). Although anomalous Au values were detected in several types of iron formation and associated sedimentary rocks, including the sulphide band on Dolly Ridge, Au-enrichment patterns appear more erratic.

Birkett's work on the Fleming Chert Breccia Formation of the Lower Proterozoic Kaniapiscau Supergroup of the Labrador Trough showed that the formation is composed of cherts, chert breccias and chert-quartz sandstones. The cherts and chert breccia are silica evaporites, primary precipitates from the Early Proterozoic ocean, and are best considered precursors to banded iron formation. The chert-quartz sandstones containing 'floating' quartz clasts represent penecontemporaneously reworked portions of the silica evaportic sequence. The potential for economic gold and platinum-group-element(PGE) mineralization in the Fleming Chert Breccia is considered poor. The potential usage of these rocks for decorative and ornamental stone or as a resource of electronic and ceramic silica is also deemed poor.

The Astray–Martin lakes area of the Labrador Trough is structurally dominated by the presence of major NW–SE-trending faults and nappe structures. Stratigraphically, the lower portion of the Kaniapiscau Supergroup consists of siliclastics/paleoplacers(?) and shallow-water carbonates (Denault Formation) that show evidence of subaerial exposure. In this area, the potential for economic mineralization is considered low with the exception of the Le Fer Formation and its equivalent in the Martin Lake area.

Gabbroic sills dominate the stratigraphy of the Howse Lake area in the central Labrador Trough. Sills were emplaced within a heterogeneous host-rock sequence formerly correlated with the Menihek Formation, but assigned by Findlay to the Le Fer Formation. The sills commonly show a well-developed internal stratigraphy defined by size and frequency distribution of plagioclase phenocrysts and glomerocrysts. Sharp, internal intrusive contacts indicate that some sills represent more than one magmatic injection.

Pyrrhotite and, to a lesser extent, chalcopyrite are ubiquitous accessory phases in all gabbroic rock types of the Howse Lake area. Local sulphide concentrations occur in several sills but are generally restricted to marginal and anorthositic rock types. Sulphide phases in places constitute up to 25% of the rock in irregular zones or, less commonly, in semi-continuous stratiform bands that range in thickness from 20 cm to 1 m. Assay results indicate that the potential for economic Au, PGE and base-metal mineralization in the Howse Lake area is low.

In the Dyke Lake–Astray Lake area, numerous thin gabbroic and ultramafic sills intrude rock types of the Knob Lake Group. The gabbros predominantly have subophitic and ophitic textures, although porphyritic, megacrystic, and branching-textured varieties of gabbro are present. The ultramafic rocks comprise a series of small lenses associated with the subophitic and megacrystic gabbros. Although poorly preserved, the primary mineralogy of the ultramafic rocks consists of approximately equal proportions of olivine and augite with minor opaque minerals. The whole-rock major- and trace-element geochemistry suggests that the gabbroic and ultramafic rocks are alkaline and similar to the mafic and intermediate lavas of the Nimish Subgroup. Minor amounts of pyrite and pyrrhotite occur in almost all samples of the gabbroic and ultramafic rocks, and analyses of 14 selected samples showed very low concentrations of Au, Pt, and Pd.

Van Gool's mapping of key areas along the Grenville Front has revealed the presence of a thin-skinned thrust belt with considerable basement involvement. The thrust belt consists of a stack of thrust sheets that were emplaced upon the Superior Province foreland in a northwest-directed thrust movement. The individual thrust sheets are some tens to several hundreds of metres in true thickness and are separated by high-strain ductile shear zones. The thrust sheets are internally deformed by folds and imbricate thrusts and locally display duplex structures. The metamorphic grade increases toward the southeast from lower greenschist facies close to the Grenville Front to amphibolite facies in structurally higher thrust sheets. The style of deformation also varies considerably in the thrust belt, with more ductile deformation occurring in the higher thrust sheets where deformation was more prolonged.

With the notable exception of the currently exploited metamorphosed Sokoman Formation, iron-ore-bearing units in the Grenville parautochthonous thrust belt appear to be of minor importance. However, the appearance of abundant hydrothermally deposited base-metal-bearing quartz veins in or near shear zones at dilation sites (i.e., cores of folds) may contain gold mineralization.

C.1.1.3 Metallogeny of Carbonate Terrane, Western Newfoundland (D.F. Sangster; T.C. Birkett)

Objectives. The purpose of this project was to investigate and compare geological characteristics of lead-zinc deposits and occurrences in the western Newfoundland carbonate platform. Geochemical and isotopic studies were also conducted on equivalent shales originally deposited in basins east of the platform carbonates. Also, groundwaters in the Newfoundland Zinc Mine area were studied with the purpose of assisting in mine-water management and mineral exploration.

Method. This project consisted of several subprojects. Mapping and basic petrography, as well as fluid-inclusion studies, were carried out on sixty-one carbonate-hosted mineral occurrences, under contract to CANNEWF Ltd. A contract to Memorial University provided for the collection and analysis of stratigraphically controlled samples from Lower Paleozoic shales (J. Botsford), to evaluate their potential for base-metal mineralization. Contracts to Memorial University used standard hydrogeological methods to measure groundwater movements and hydraulic heads in the vicinity of the Newfoundland Zinc Mine (J. Gale and J. Whelan), to provide a better understanding of mineral-exploration guidelines used in locating further Pb–Zn deposits on the Great Northern Peninsula.

Results. A major result of the carbonate study revealed that the mineral occurrences can be grouped into two broad types: 1) typical Mississippi Valley type (MVT), similar to the Newfoundland Zinc deposit, where the amount of sulphides and gangue is a function of the secondary porosity of the rocks, which decreases with their age; and 2) a vein–open-space-filling type associated with calcite and barite gangue. Mineralization is confined to veins in less permeable Cambrian and Ordovician strata and tends to fill open spaces in more permeable Mississippi rocks. Only the first type appears to have economic potential in Newfoundland. The fluid-inclusion studies revealed a wide range in homogenization temperatures and salinities; interpretation of these data is still in progress.

The shale study showed that a pronounced Lower Ordovician transition from anoxic-stratified to highly ventilated sedimentary conditions is particularly evident in the Northern Head Group. Anomalous base-metal concentrations in the anoxic interval may indicate a high potential for exhalative sedimentary deposits. The overlying oxygenated interval is, by contrast, relatively base-metal poor, but correlates in time with carbonate host rocks to base-metal deposits in platform carbonates. This coincidence may indicate metals were mobile during the ventilated episode and hence available for transport out of the shale basin and into correlative carbonates.

The study of the fracture pattern in the mine area revealed that three major fracture sets control groundwater flow. Two of these are steeply dipping joints, whereas the third represents a bedding plane. Direction of flow is toward the mine workings as a result of sustained mine drawdown. Hydraulic-head contours outline a drawdown cone with a northeastward-directed axis. Groundwaters are of the calcium-bicarbonate type and are the result of dissolution of carbonate rocks. Two main types have been identified: 1) shallow, low total-dissolved solids typical of shallow boreholes and shallow mine inflows; and 2) chemically evolved, highly saline waters. Several lakes were identified as discharge lakes and are potential sites for accumulation of dissolved trace metals transported by groundwater. Thus, recognition of discharge lakes could be used in the exploration for buried deposits of the Newfoundland Zinc type (MVT).

C.1.1.4 Metallogeny of Buchans–Roberts Arm Belt (H.S. Swinden)

Objectives. The purpose of this project was to conduct a regional metallogenic study of volcanic and sedimentary rocks of the Buchans–Robert's Arm volcanic belt and related volcanic rocks in western Notre Dame Bay; to classify the known mineral deposits and to compare and contrast similar deposits throughout the belt; to determine the geological setting and genesis of the various deposit types and develop geological criteria by which they can be distinguished; to better understand the plate-tectonic controls on massive sulphide deposition; and to use this understanding to attempt predictive metallogeny for economically attractive deposit types.

Methods. The project included a number of subprojects that were operated more or less independently. The results have been integrated into regional metallogenic models.

Regional geological mapping (1:12,500 scale) in the southern and central Robert's Arm Group, and deposit-level investigations throughout the Robert's Arm Group were carried out by H.S. Swinden and assistants in 1985 and 1986. Geological investigations and deposit-level studies in the Frozen Ocean, Cottrell's Cove, Chanceport and Sleepy Cove groups were carried out in 1987. Work included detailed and regional geological mapping, sampling of mineralized and unmineralized volcanic rocks for whole-rock geochemical studies, detailed deposit studies and geochronology.

Detailed structural studies in the Buchans Mine area were contracted to T. Calon of Memorial University. Field work involved study of outcrops and drill core by Calon and K. Greene in 1985 and by Greene in 1986.

Structural, stratigraphic and geochemical studies in the Catcher's Pond and Cutwell groups were done by Z.A. Szybinski (Ph.D. student, Memorial University). Field mapping, structural and whole-rock geochemical studies were contracted to G.A. Jenner of Memorial University in 1986.

The compilation of a pre-Silurian metallogenic map for central Newfoundland was a joint Newfoundland Department of Mines and Energy and Geological Survey of Canada project carried out by D. Evans and supervised by Swinden and B.F. Kean (NDME).

Finally, detailed petrographic, microprobe and fluid-inclusion studies were carried out on selected deposits.

Results. The main scientific results were as follows:

1) A new structural interpretation of the Buchans mining camp, which has had an immediate impact on exploration in the mine area.

2) Recognition that the Frozen Ocean Group is probably not part of the Buchans–Robert's Arm belt, but includes elements of older oceanic and younger terrestrial volcanic and sedimentary rocks.

3) Recognition of a structurally controlled gold-mineralization event in the Robert's Arm Group, probably correlative with other gold-bearing environments in central Newfoundland, and initial volcanogenic mineralization that is prevalent throughout the belt.

4) Documentation of deposit and alteration types throughout the Robert's Arm Group, classification and recognition of sub-types within the two major deposit classes (volcanogenic and epigenetic).

Plate 8. *An intrusion breccia occurs where the Twin Lakes granodiorite intrudes mafic volcanic rocks of the Robert's Arm Group along the east shore of Great Gull Lake.*

5) Documentation of the geochemistry of volcanic rocks throughout the belt, recognition of distinctive volcanic rocks that are characteristically associated with ore at Buchans and Pilley's Island, and documentation of similar rocks elsewhere in the belt. This may provide an immediate aid for focusing exploration in the belt.

6) Revised structural and stratigraphic models for the Catcher's Pond and Cutwell groups that provide new geological concepts for focusing exploration in these sequences (particularly, the recognition of structural repetition of mineralized rocks in the Cutwell Group and correlation of these with probable equivalents in the Catcher's Pond Group).

7) Mapping and age dating of Hall Hill and Mansfield Cove Complex showing them to be almost coeval with Robert's Arm Group, possibly contemporary oceanic basement. Mafic volcanic rocks in this unit may constitute a heretofore untested target for cupriferous massive sulphides.

C.1.1.5 Metallogeny of Newfoundland Ophiolites (J.W. Lydon)

Objectives. The purpose of the project was to evaluate the potential of ophiolitic rocks in the Bay of Islands, Baie Verte and Gander River areas for precious-metal, base-metal, chromite, and industrial-mineral deposits, and to formulate genetic models and exploration methods that will lead to the discovery of new mineral deposits of ophiolitic affiliation.

Methods. Through systematic field mapping, sampling and follow-up laboratory investigations (geochemistry, geochronology and isotopic analyses), the metallogenic and geological processes that characterize ore formation in Newfoundland ophiolites were documented.

Results. Bay of Islands Ophiolite. A large part of the Lewis Hills Massif was mapped by S.M. Dunsworth and T. Calon (Memorial University) with emphasis on the tectonic and magmatic history of the plutonic part of the ophiolite. Based on innovative techniques, they determined that the formation of these rocks involved deformation synchronous with magma emplacement as the upper part of the mantle and oceanic crust moved away from a crustal spreading centre. Some of the mechanisms of deformation, especially at the microscopic level, were studied by G. Suhr (Memorial University of Newfoundland) and R. Dahl (Carleton University). P.L. Schwann (Geological Survey of Canada) studied the petrology and chemistry of chromite deposits. S. Edwards and J. Malpas (both of Memorial University) studied the chemical evolution of the magmas, with emphasis on the behaviour of platinum-group elements during melting and crystallization of the rocks. R. Talkington (Carleton University) documented the general distribution of platinum-group elements in chromite and J.W. Lydon (GSC) investigated magmatic sulphide concentrations.

Plate 9. *Harzburgite containing dunite bands in Springers Hill region of the Lewis Hills Massif, overlooking Fox Island River.*

This integrated project discovered processes of magmatic concentration of platinum-group elements that are new for ophiolites. The one documented by S. Edwards is associated with the formation of orthopyroxenites and the other documented by J.W. Lydon involves the interaction of hydrous fluids with gabbros at magmatic temperatures. More research is needed to determine if these processes give rise to viable exploration targets. The structural investigations concluded that because chromite concentrations form at an early stage in the history of the ophiolites, they become too dismembered during subsequent complex deformation to be viable exploration targets.

Baie Verte Peninsula. Investigations were mainly directed toward the potential for shear-zone-related gold mineralization. Emphasis was placed on the documentation of the geochemical expressions of hydrothermal events, and participants included T. Al, K.A. Hudson, J.G. Lavigne, and J.W. Lydon. In addition to this work, C.M. Saunders and D.F. Strong (Memorial University) completed a detailed geochemical study of ophiolitic sulphide mineralization at Tilt Cove. Several gold discoveries were made during the course of the project. Also, the project has identified the geological controls and timing of the gold mineralization, and provided useful exploration criteria.

The Baie Verte Peninsula was also the site for investigations related to hydrothermal platinum deposits, and it was demonstrated that platinum is concentrated by serpentinization/carbonitization of ultramafic rocks. However, it remains to be demonstrated that the process generates viable exploration targets.

Gander River. Geological mapping (1:50,000 scale) of the ultramafic and gabbroic rocks of the Great Bend area was completed by E.J. Zwicker and D.F. Strong through a contract with Memorial University of Newfoundland. It was discovered that a belt of sedimentary rocks separates the gabbroic from the ultramafic rocks, suggesting the possibility that the two suites of igneous rocks may have separate emplacement histories and even separate origins. The mapping has significantly increased the extent of the known talc–magnesite zones and has substantiated the suggestion of earlier workers that the mineralization is controlled by fault and shear zones. Chromite lenses and pods are common throughout the serpentinized harzburgites and dunites. Pyrite and arsenopyrite, occurring both in association with quartz veins and also in zones disseminated in sedimentary rocks surrounding the ophiolite, have some potential for gold mineralization.

C.1.1.7 Analytical Services Support (A.G. Plant)

Objectives. The purpose of the project was to provide sample preparation and analytical support to the Federal projects by arranging and scheduling contracts for chemical analyses, isotope analyses and other services as required.

Methods. Contracts with X-ray Assay Laboratories Ltd. in Don Mills, Neutron Activation Services Ltd. in Hamilton, and Bondar-Clegg and Company Ltd. in Ottawa were utilized to support the various projects for sample preparation and the determination of major elements and selected minor and trace elements. Data for the determination of sulphur isotopes in sulphides were obtained by contract with the University of Ottawa. Approximately $292,000 was committed and/or expended during the 1984-89 period for contract analyses, sample preparation, shipping, and the purchase of materials and supplies. Miscellaneous mineralogical support for the projects was provided by the Mineralogy Section of the Geological Survey of Canada.

Results. Approximately 5,023 samples were analyzed by contract and the analytical data were provided directly to project geologists for use in their studies and presentation in their publications.

C.1.1.8 Chetwynd Geochronology (H.S. Swinden; T.C. Birkett)

Objectives. The purpose of the project was to provide accurate and precise radiometric dates for rocks in the immediate area of the Hope Brook Mine, so as to better understand the stratigraphic and structural setting of the deposit and the timing of the alteration and gold mineralization. This was an attempt to place the various rock types, deformation, and mineralization in a regional temporal framework, and to develop genetic models for the mineralization based on this framework, thereby helping focus exploration for similar deposits elsewhere in southwestern Newfoundland.

Methods. This project was part of an integrated geochronological program funded by the Geological Survey of Canada, the Newfoundland Department of Mines and Energy and BP Mining. Samples were collected by H.S. Swinden, G.R. Dunning of the Royal Ontario Museum, B.H. O'Brien (Newfoundland Department of Mines and Energy) and Peter Stewart (Ph.D. student, University of Western Ontario) during the summer of 1987. Rocks from felsite within the alteration zone were dated by U–Pb in zircon to provide a lower limit on the mineralization age. Felsic tuffs in the nearby volcano-sedimentary sequence were similarly dated in an attempt to pinpoint the boundary in the immediate mine area between Precambrian rocks to the southeast and Silurian rocks to the northwest. Rutile separates from the Hope Brook alteration zone were dated by the U–Pb method in an attempt to directly determine the age of mineralization.

Results. This geochronology study helped to demonstrate that much, if not all, of the Hope Brook alteration zone is developed in Precambrian rocks. Dating of the nearby felsic tuff has shown that a previously unrecognized but very important structural boundary passes through or very near to the Hope Brook alteration, affecting the Hope Brook zone. This indicates a very complex structural and alteration history for the area. In association with other geochronological and geological studies in the area, this work has contributed to a proposal of a major shear-zone model for the mineralization, which is currently being applied in gold exploration in southwestern Newfoundland and Cape Breton.

C.1.2 GEOLOGICAL INVESTIGATIONS

C.1.2.1 Geology of Southern Long Range (K.L. Currie)

Objectives. The purpose of the project was to map and describe the metamorphic and plutonic rocks of the southern Long Range Mountains within NTS map areas 12B/1,2,8 and 9 (of secondary importance, to check and compile the geology of NTS map areas 12A/5 and 12); to evaluate the mineral potential of these areas; to integrate the results into tectonic models of the northern Appalachians; and to determine the age and petrogenesis of the plutonic rocks and their relation to metamorphism.

Methods. During 1985 through 1988, field mapping, petrography, petrology and geochemistry was carried out by J. van Berkel (then with the Geological Survey of Canada) and field assistants. At the same time, K.L. Currie (GSC) completed a study on the geochronology of igneous rocks in the southern Long Range, and M.A.J. Piasecki (University of Hull, United Kingdom) undertook kinematic analysis of shear zones.

Results. The area can be subdivided into five terranes that are separated by major high-strain zones. The latter are generally steeply dipping and have a complex ductile–brittle movement history, including transcurrent and thrust movements. Northwest of the Long Range fault zone, Late Proterozoic to Cambrian metasedimentary rocks (Fleur de Lys Group correlatives) and underlying Grenvillian gneisses of the Steel Mountain Terrane, both forming part of the Humber Zone, have been thrust to the northwest. The Central Gneiss Terrane, between the Long Range fault zone and the Lloyds River fault to the east, occupies most of the map area. Its dominantly quartzofeldspathic gneisses have similarities to Gander Zone metasedimentary rocks. East of the Lloyds River fault, the Dunnage Zone is represented by the low-grade volcanic rocks and associated sedimentary rocks of the Victoria Lake Terrane and the Topsails Terrane. Quartzofeldspathic gneisses and minor volcanic rocks define the Rocky Ridge Pond Terrane in the southeasternmost part of the map area.

The area east of the Long Range fault zone is characterized by a relatively large number of postmetamorphic mafic intrusives.

Quartz veins associated with high-strain zones and ultramafic slices locally contain significant gold values and emphasize the mineral potential of the major shear zones in the map area. Small Cr–Au–Pt–Pd concentrations occur in ultramafic and mafic tectonic slices within the quartzofeldspathic gneisses of the Central Gneiss Terrane.

C.1.2.2 Geology of Northern Long Range (K.L. Currie)

Objectives. The purpose of the project was to map and describe the metamorphic and plutonic rocks of the Precambrian northern Long Range Mountains at 1:100,000 scale; to complete the systematic mapping of northwestern Newfoundland; to evaluate the mineral potential of the area; and to integrate the acquired data with the published mapping results by H.H. Bostock in a study of the entire area to determine its geological evolution.

Methods. P. Erdmer (contractor) mapped part of the Long Range Mountains in NTS map area 12H with emphasis on the structural and metamorphic history. V. Owen (visiting fellow) studied a large gabbro–anorthosite complex and surrounding rocks with emphasis on petrochemistry and metamorphism. V. Owen, under a contract to Saint Mary's University, continued and completed mapping the Long Range Mountains and studied the Long Range dyke swarm.

Results. Mapping of the Long Range Inlier within NTS map areas 12H and 12I was completed. The inlier consists mainly of granulite-grade ortho- and paragneisses older than ca. 1500 Ma. The gneisses were intruded by large, composite, commonly megacrystic, granitoid plutons of ca. 1040 Ma, and the Late Precambrian Long Range dyke swarm (ca. 605 Ma). The granulites are progressively retrogressed from west to east due to the superimposed Paleozoic deformation and

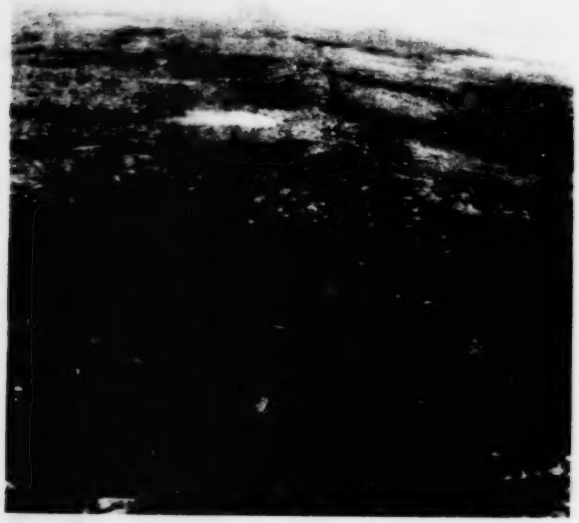


Plate 10. *A northeast-trending Long Range dyke intrudes high-grade granitic gneisses in the northeastern part of the Grenville inlier.*

metamorphism (probably Acadian), which also affect the Long Range dyke swarm.

Significant gold mineralization is associated with the Paleozoic deformation and Devonian plutonism along the eastern edge of the inlier. The deformation may have involved some thrusting on the western and eastern edges of the inlier, but the inlier appears to have an overall autochthonous to parautochthonous character with respect to the Appalachian foreland.

C.1.3 REGIONAL GEOCHEMISTRY

C.1.3.1 Regional Geochemical Reconnaissance, Labrador (E.H.W. Hornbrook; P.W.B. Friske)

Objectives. The purpose of the project was to provide geochemical reconnaissance maps of Labrador, which would encourage and stimulate the search for a variety of mineral commodities by the mineral-exploration industry; to develop computer-assisted methods of managing and preparing preliminary interpretations of large datasets, thereby producing clear, easy-to-interpret, affordable open files to the public soon after receiving analytical data from commercial labs; and to build a national geochemical database for use in resource assessment, environmental studies and geological mapping.

Methods. The Labrador study consisted of three components: regional reconnaissance surveys **(Project C.1.3.1)**, a re-analysis program to provide analyses of a more complete set of elements **(Project C.1.3.3 Additional Analyses of Archived Samples)**, and a high-density infill survey. Regional helicopter-supported reconnaissance surveys sampled lake-bottom sediments or stream sediments (the latter only in northernmost Labrador, north of latitude 58° 30') at approximately one sample per 13 km², and delineated areas where concentrations of economically important elements or their associated 'pathfinder' elements were anomalous. Water samples from each site were analyzed for uranium, fluoride and pH values. The re-analysis program employed non-destructive neutron-activation analysis to determine concentrations of gold and 33 other elements in previously analyzed archived samples. An infill survey, with a sampling density of one lake- and stream-sediment sample per 3 to 5 km², was conducted across an anomalous zone near Makkovik outlined in a previous reconnaissance survey.

E.H.W. Hornbrook directed the collection of samples for reconnaissance surveys by contractors, selected each year through competitive bidding. Direct supervision of the contract surveys was provided by P.W.B. Friske. Infill-survey samples were collected in 1987 by Geological Survey of Canada personnel. The samples were prepared and analyzed by contract laboratories.

Open-file reports for each survey were prepared during winter and early spring for release the following summer. Until 1987, open-file releases consisted of sets of 1:250,000-scale whiteprints with accompanying text, but in 1988 a new format was introduced using computer software developed by GSC personnel.

Results. Since the completion of the 1986 stream-sediment survey, the entire region of Labrador has been covered by drainage geochemical reconnaissance surveys at a sampling density of one sample per 13 km². During the 1984-1989 period, 106,400 km² of Labrador have been geochemically surveyed. Of this area, approximately 50,000 km² were surveyed for gold. These results were directly responsible for mineral claim staking.

A new method of presenting geochemical data using personal computers instead of relying on expensive mainframe computers has eliminated labour-intensive cartography, resulting in convenient open-file outputs costing a quarter of their former price.

Work continues on new and better methods of presenting analytical data. Advances in computer technology, particularly development of the geographic information systems (GIS), have provided new cost-effective tools to cope with voluminous regional geochemical data. GIS computer programs are being adapted to store, retrieve, manipulate and display spatial geoscientific data in a manner that will greatly expedite production of open files.

C.1.3.2 Follow-up of Regional Geochemical Anomalies (E.H.W. Hornbrook)

Objectives. The purpose of this project was to investigate regional geochemical anomalies from published and current data, to determine the cause of the anomalies, to develop exploration follow-up methodology for use by the mineral industry, and to aid and encourage mineral exploration. *This project was transferred to the Newfoundland Department of Mines and Energy in April, 1986.*

C.1.4 GEOPHYSICS

C.1.4.1 Airborne Gamma-Ray Spectrometry and VLF Surveys (K.S. Richardson)

Objectives. The purpose of this project was to produce airborne gamma-ray spectrometer maps and associated total-field magnetic and VLF-EM profiles for selected parts of insular Newfoundland. These maps depict the distribution of the three most common, naturally occurring radioelements (K, U and Th) and their associated ratios, providing an aid to regional and detailed bedrock and surficial geological mapping, multi-element mineral exploration and environmental radiation monitoring.

Methods. The project was carried out using the Geological Survey of Canada's Skyvan aircraft and by contract to Sander Geophysics Ltd. with technical supervision by the GSC. All surveys were flown with a flight-line spacing of 1 km and an optimum terrain clearance of 122 m. Surveys were flown in 1984 (southwest Newfoundland, parts of NTS map areas 11O, P; 12A and B) and 1985 (south central Newfoundland, parts of NTS map areas 1M, 2D and 11P) by the GSC aircraft, and in 1987 (Great Northern Peninsula, parts of NTS map areas 12H and 12I) by Sander Geophysics Ltd. In 1987 and 1988, the GSC flew surveys in the Gander–Botwood (parts of NTS map areas 2C, D, E and F) and Baie Verte (parts of NTS map areas 2E, 2L; 12H and 12I) areas respectively with GSC regular funds. Survey results are published as 1:50,000-scale contour maps of seven radiometric parameters [total-count exposure rate, potassium (percentage), equivalent uranium (ppm), equivalent thorium (ppm), equivalent uranium–equivalent thorium, equivalent uranium–potassium, and equivalent thorium–potassium]. The maps are accompanied by a booklet of stacked profiles that include the seven radiometric parameters along with a total-field magnetic profile, two VLF-EM profiles (total field and Quadrature) and a terrain-clearance profile.

Results. Currently, 60 percent of insular Newfoundland has been covered by regional (1-km line spacing) airborne surveys. The radioelement-distribution patterns defined by these surveys have demonstrated applications to regional and detailed bedrock and surficial geological mapping. Mapping of the regional radioelement variations identifies those rock types that are characterized by similar proportions of the three radioelements, or may indicate variations in the radioelement signature of a particular rock type previously mapped as homogeneous. In areas where the different bedrock units have sufficient radioelement contrast, the airborne surveys are also an excellent predictive tool for mapping the overlying surficial deposits.

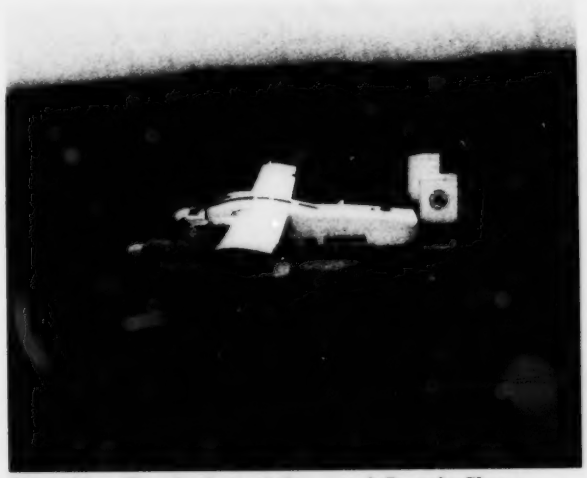


Plate 11. *The Geological Survey of Canada Skyvan.*

The airborne-survey results can also be of direct assistance to exploration for a variety of lithophile mineral commodities, e.g., U, Sn, W, REE, Be, Li and Zr. In special cases, survey results can also be applied to precious-metal and base-metal exploration where the normal radioelement signature of the rock unit that hosts the mineralization has been sufficiently altered by the mineralizing process.

These results provided an excellent opportunity to develop and test a modified ternary-radioelement mapping technique. This technique was designed to optimize the presentation of four radioelement parameters on a single map, thus enhancing further the application of this method to geological mapping and mineral exploration.

C.1.4.2 Aeromagnetic, Gradiometer, VLF-EM surveys (E.E. Ready)

Objectives. The purpose of the project was to carry out detailed aeromagnetic, gradiometer and VLF surveys as an aid to detailed geological mapping of selected parts of Newfoundland.

Methods. Surveys were contracted to Questor Surveys Ltd. in 1984-85 and Aerodat Ltd. in 1986-87. Results were to be made available as 1:25,000-scale contour maps of magnetic total field and vertical gradient, 1:50,000 colour-

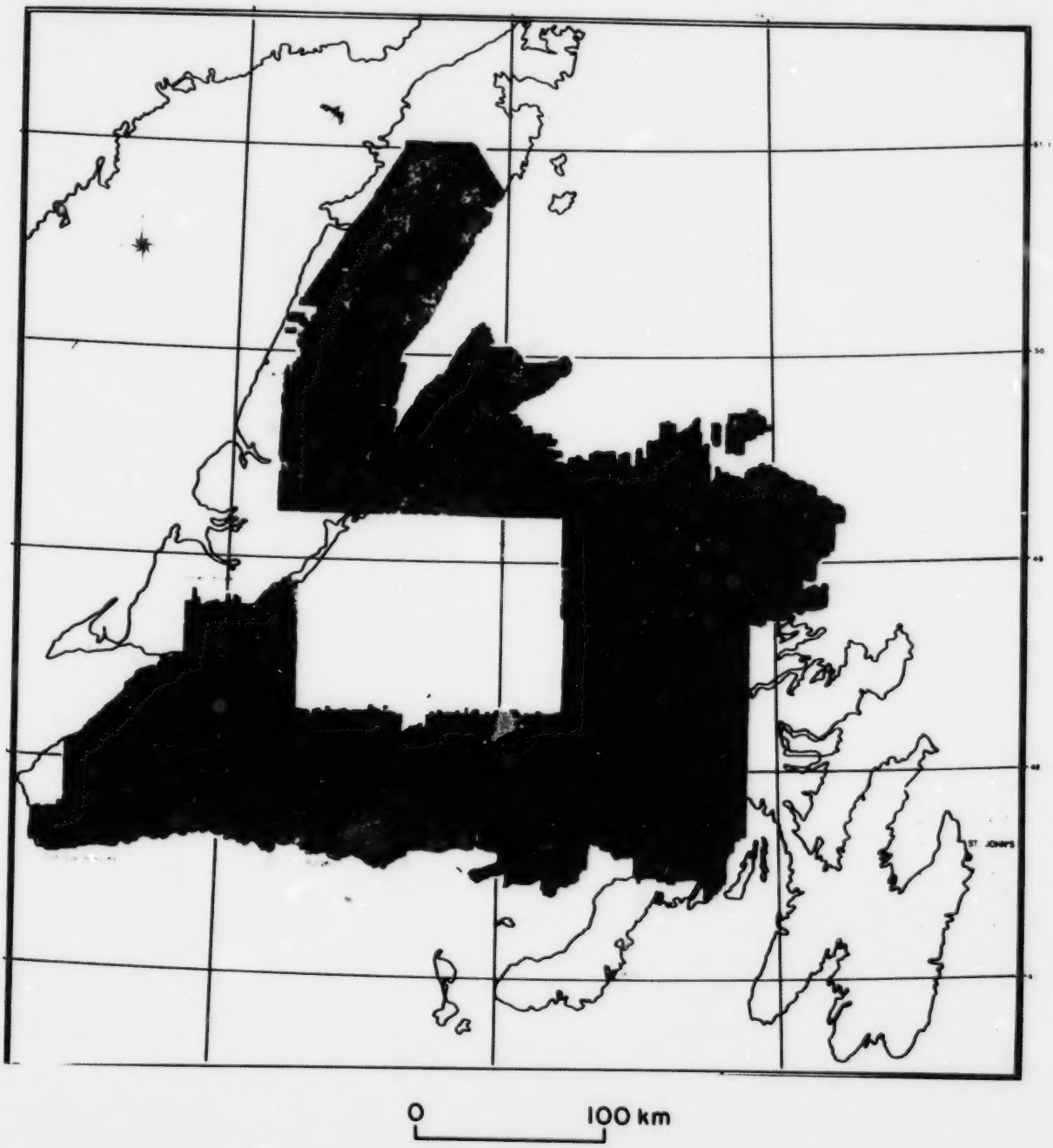


Figure 2. *Radioactivity map of the Island of Newfoundland. Areas of high natural radioactivity form the purple, red and orange areas, whereas the blue areas are low in naturally occurring radioactive elements. Exposure (μR/H). Compiled from 1-km-line-spaced airborne gamma-ray spectrometer surveys carried out by the Geological Survey of Canada.*

interval maps of magnetic total field and vertical gradient with VLF-EM profiles printed on reverse side of maps, and digital data on tape.

Results. Project results were used as input for further study and mapping projects. For example, Project N.1.4.1 (G. Kilfoil) was initiated to enhance and interpret, through use of an image-analysis system, the coverage southwest of Buchans–Badger and in the Notre Dame Bay area. Magnetic and VLF ground follow-up was coordinated with project geologists for the 1988 field season.

Survey results for the Lake Ambrose and Springdale area were published as high-resolution aeromagnetic total-field and vertical-gradient maps (at 1:25,000 scale), along with combined aeromagnetic total field with VLF-EM total-field profiles (at 1:50,000 scale), and combined aeromagnetic vertical-gradient and VLF-EM quadrature profiles (at 1:50,000 scale).

C.1.4.3 Geophysical Tests of Selected Mines (P.G. Killeen; C.J. Mwenifumbo)

Objectives. The purpose of the project was to conduct geophysical tests (ground and borehole) of Newfoundland Zinc, Rambler and Buchans mines, in order to select the best method for detecting orebodies. A variety of methods was used.

Methods. Mine-site visits were initiated in order to select suitable holes for logging and to plan subsequent logging expeditions during summer field work (1984-1988). Logging included single-hole multiparameter measurements and hole-to-hole electrical measurements. Single-hole multiparameter borehole measurements included induced polarization (IP), resistivity, self potential (SP), magnetic susceptibility, spectral gamma–gamma (density and spectral ratio for detection of heavy elements), natural-gamma-ray spectrometry, and high-sensitivity temperature logging. Processing of the logging data was carried out with the help of students. Log analysis and interpretation were carried out by C.J. Mwenifumbo and P.G. Killeen.

Results. Buchans Mine. Borehole geophysical measurements in the Buchans Mine area consisted of: underground *mise-à-la-masse* measurements in the Maclean extension orebody; natural-gamma-ray and temperature logging at the Mudhole Prospect; and resistivity/IP/SP, temperature and natural-gamma-ray logging at the Clementine Prospect.

The natural-gamma-ray logs proved very useful in mapping various volcanic units, some of which were not easily identifiable in drill core. Stratigraphic correlation of different volcanic units may be greatly improved with the use of these logs. Continuity and orientation of ore intersections in a number of drillholes in the Maclean extension orebody were easily determined from the *mise-à-la-masse* measurements.

Rambler Mine. The mine was visited in the Spring of 1986. Since no suitable open holes were available, no further work was done.

Newfoundland Zinc Mine. Significant results of the logging at the Newfoundland Zinc Mine include the following:

1) Spectral gamma–gamma logs clearly defined sphalerite-rich zones. This application of a new borehole-logging technique was able to give a much more detailed picture of the zinc distribution than the core-assay information.

2) Natural-gamma-ray logs were very useful in stratigraphic mapping. The location and vertical displacement of one of the faults running through the 'N' zone was easily determined from the logging data.

3) Although sphalerite mineralization does not respond well to electrical methods of exploration, IP logs indicated that significant chargeability values were associated with the mineralization, suggesting that the IP method may be used in exploration for sphalerite at this mine.

4) Temperature logging provided significant water-flow information that may be of use to the mine engineer.

C.1.5 OVERBURDEN STUDIES

C.1.5.1 Glacial History and Drift-Prospecting Studies, Labrador (R.A. Klassen)

Objectives. The purpose of the project was to establish ice-flow history, and develop models of glacial dispersal throughout southern Labrador as a Quaternary geological basis for mineral exploration by drift prospecting.

Methods. In the field, ice-flow indicators, such as striae and glacially streamlined landforms, were mapped to establish trends and relative ages of ice flow. Glacial sediments, till in particular, were sampled to develop models of glacial-dispersal patterns and to develop techniques of sampling and analyses. Field studies during the summers of 1984-1988 were under the technical direction of F.J. Thompson. Compositional analyses of geochemical, mineralogical, and lithological properties of till were carried out within Geological Survey of Canada laboratories, and by contract with Bondar-Clegg and Co. Ltd. (Ottawa), Chemex Ltd. (Vancouver and Toronto), Consor Mines Ltd. (Hull), and Wyatt Geoscience Ltd (Ottawa). Quaternary geological maps of western Labrador (1:250,000 scale) and of Labrador and adjacent Quebec (1:100,000 scale) were produced by review of aerial photographs by GSC personnel and under contract

with Terrain Analyses Services. Geochemical symbol maps have been produced by Wyatt Geoscience Ltd.

Results. This study has provided an unprecedented opportunity to review the Quaternary geology of Labrador and to establish a geological basis for drift prospecting within the region. It has established directions and distances of glacial transport and has developed models of glacial dispersal that are directly applicable to mineral exploration. The work has shown that drift composition is the geological record of a complex ice-flow history that was previously unrecognized. Models of glacial dispersal that are based on the distributions of 'indicator erratics' illustrate how distances and directions of glacial transport vary with geographic location within the ice sheet. For example, near the ice-sheet margins, along the Labrador coast, dispersal patterns are simple and appear as ribbons streamed down-ice from their bedrock sources in the directions of 'last' ice flow. To the west, closer to major dispersal centres of the Labradorean ice sheet, dispersal patterns become increasingly complex, and vary from broad 'fans' opening down-ice to irregular 'patches' centred about the source. Such variation clearly affects the interpretation of till geochemical values for exploration purposes.

This work provides the first basis for distinguishing the effects of glacial dispersal from bedrock composition within regional geochemical surveys of Labrador. Glacial dispersal affects drift composition at all scales of investigation, from regional (hundreds of kilometres) to detailed (tens of metres to a kilometre). The compositional influence of supracrustal sequences in particular can be recognized in surficial sediments tens to hundreds of kilometres from their source. Supracrustal rocks are easily eroded by the ice sheet in comparison with crystalline bedrock, and are preferentially concentrated within the finer size fractions that are most commonly subject to geochemical analyses. In western Labrador, for example, debris from the Labrador Trough is a dominant component of till overlying crystalline bedrock of the Ashuanipi Highlands. There, the debris dominates the till composition more than 40 km from the source and masks the geochemical patterns of underlying bedrock. Where glacial influences are more limited, geochemical patterns can indicate compositional variations within bedrock that otherwise appears to be compositionally uniform, and may provide a basis for estimating mineral potential and establishing the focus of exploration effort.

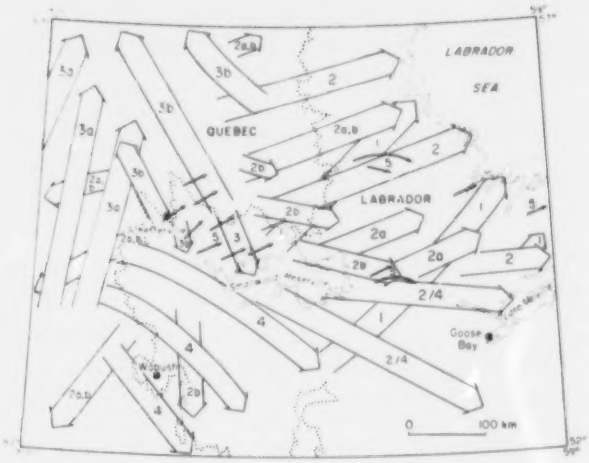


Figure 3. *Schematic summary of ice-flow history illustrating large-scale ice-flow events and their areas of influence, based on striae and the dispersal of erratics. Flow events are numbered from oldest (1) to youngest (5).*

Methods of sampling and of geochemical analyses have been developed that are appropriate to geochemical exploration within Labrador, where postglacial weathering and soil development can significantly affect till geochemistry, further altering its compositional relationship with bedrock.

A geological framework for mineral exploration has been provided by: a) description of ice-flow direction and glacial-dispersal patterns, b) distinguishing the effects of glacial dispersal and bedrock composition on regional till geochemistry, and c) recognition of geochemical variations within and among large bedrock units. Exploration in Labrador has been largely conducted in areas where surficial sediments are thin, presenting little hinderance to exploration.

2. MINING AND MINERALS TECHNOLOGY

C.2.1 DEPOSIT ASSESSMENT

C.2.1.1 Selection of Mineral Deposits in Newfoundland Suitable for Research (J. Jambor)

Objectives. The purpose of the project was to achieve definitive mineralogical and metallurgical assessments of deposits that are likely to be developed in future, and also to evaluate the commercial potential and metallurgical problems related to the development of mineral-processing flowsheets for these deposits. Meeting these objectives should lead to assessing the potential of deposits and contribute to the further development of the mineral industry in Newfoundland and Labrador.

Methods. The project began with a study on 'Selection of Mineral Deposits in Newfoundland Suitable for Research'. The investigation involved a review of all publicly available data on both metallic and industrial-mineral deposits, as well as discussions with geoscientists of different companies and the government. Nineteen deposits that met a list of accepted

criteria were evaluated. Nolan Davis and Associates Ltd., a private consulting firm, were contracted to undertake the study.

Results. Of the nineteen deposits evaluated, the Point Leamington polymetallic deposit was immediately recognized as suitable for detailed investigations, and this work was initiated concurrently with the overall review. The project also led to the selection of quartzite deposits in the vicinity of Labrador City and the Tulks Hill polymetallic base-metal deposit as being suitable for further research.

C.2.1.2 Evaluation of the Point C.2.1.3 Leamington Deposit–Phase I: Sampling; Phase II: Mineralogy and Small Pilot Tests (J. Jambor)

Objectives. The purpose of the project was to advance scientific and evaluation techniques by providing an indication of state-of-the-art progress in conventional processing of fine-grained sulphide ores.

Methods. The Point Leamington deposit was discovered and developed by Noranda Exploration Co. Ltd. in a joint venture arrangement with Newfoundland and Labrador Corp. Ltd., the original holders of the mineral rights to the area. Feasibility studies and preliminary metallogical tests undertaken in the mid 70's produced low metal recoveries and grades of concentrates, and concluded the deposit was subeconomic. Private exploration work in the intervening years was aimed at delineating a higher grade zone(s) with economic possibilities within the main sulphide body. The current study set out to re-evaluate the economics of a low-grade, high-tonnage and high-employment development of the deposit, rather than a small higher grade operation. It was thought that updated testing methods in combination with quantitative mineralogy, and in particular novel sophisticated methods developed to a great extent at the Canada Centre for Mineral and Energy Technology and available also at the New Brunswick Research and Productivity Council, would provide an updated assessment of the economics of the deposit. This updated assessment would include mineralogical–metallurgical pilot tests followed by a preliminary economic viability assessment.

On-site sampling of the deposit was undertaken by Nolan Davis and Associates Ltd. Mineralogy and pilot test work was contracted to the Noranda Research Centre.

Results. The total ore reserves of the Point Leamington deposit are estimated at 13.2 million tonnes (2.25% Zn) including only 1.5 million tonnes of high-grade (7.3% Zn, 2.25 ppm Au, 0.43% Cu) ore.

Tests of material from the High Zinc Zone showed that at very fine primary grinds of about 90% minus-400 mesh, Zn recovery was approximately 85% and Cu recovery about 50%; the Zn concentrate grade was about 54% Zn, the Cu concentrate grade about 20%. These results indicate that satisfactory recovery levels and concentrate grades are attainable from the High Zinc Zone, provided that the grind is very fine.

Zinc results for the low-grade samples were considerably inferior–50% concentrate at about 60% recovery. Gold and silver recoveries to the Cu concentrate were poor at 10% or less.

A preliminary economic analysis found little promise for the deposit without the discovery of considerable additional tonnages of high-grade material.

Noranda considered first results of this study as promising and continued drilling and sampling the deposit within their own budget. To-date, however, no results have been achieved that would lead to a commercial development.

C.2.1.4 Assessment of Silica Deposit (R. Collings)

Objectives. The goal of the Labrador City Silica Project was to determine whether the grades of the deposit can be improved, and to assess the possible range of silica/silicon products that could be produced from this silica resource.

Methods. Samples (borehole carrots) from the 'Fermont Highway' and from the '2907 Hill' deposits were collected and analyzed for this purpose. The sampling and evaluation was conducted by Golder Associates Ltd.

Results. The easily accessible 'Fermont Highway' silica deposit contains two million tonnes of friable quartzite with 97.9% SiO_2, 0.24% Fe and 0.48% Al_2O_3. This result led to further economical studies carried out under the CNMDA Economic Development Studies. A commercial development of this deposit is very probable.

The '2907 Hill' deposit consists of 15 million tonnes of solid quartzite with over 97.5% SiO_2, 0.22% Fe and 0.3% Al_2O_3. It is not easily accessible and the cost of exploitation and grinding would be much higher than for the 'Fermont Highway' deposit. Its cost of development could be relatively high and therefore prohibitive.

C.2.2 EVALUATION OF AGGREGATES

C.2.2.1 Evaluation of Aggregates for Potential Alkali–Reactivity (J.A. Soles)

Objectives. The purpose of this project was to provide a preliminary assessment of the degree to which rock types in Newfoundland are subject to

adverse reactions with cement alkalis when used as aggregates in Portland cement concrete, and to obtain the reaction potential of aggregates currently used by ready-mix concrete producers. Also, data were to be collected on potential aggregate sources that may be considered for use in future offshore structures.

Methods. Samples provided by the Newfoundland Department of Mines and Energy, as well as those collected by this project, underwent petrographic and mineralogical studies. Standard acceptance tests of concrete made with selected aggregates were performed, and deteriorated concrete structures examined. The project was carried out by Golder Associates Ltd.

Results. Limited evidence of the alkali reactivity was observed in most of the bridge structures examined. A moderate to strong degree of reactivity was, however, detected in the concrete from several bridges in the head of Placentia Bay–Clarenville area.

The routine laboratory tests confirmed that the aggregates and rock samples tested meet normal durability requirements. The laboratory expansion tests indicate that most of the samples exhibit slight to moderate potential for expansion in Portland cement concrete. About one quarter of the samples showed very low expansion. All the expansions recorded were less than the maximum limits currently recommended in Canada. No highly reactive rock types were tested.

C.2.2.2 Mechanical Properties and Long-Term Durability of Concrete with Local Aggregates and Cements for Potential Applications in Offshore Structures (V.M. Malhotra)

Objectives. The purpose of this project was to develop an engineering database for concretes made with local materials from selected sources. It was aimed, in particular, at providing information that designers of offshore and other structures could use for preliminary calculation of high-strength concrete elements.

The broader objective of this project was to assist the construction industry in Newfoundland by assessing the alkali reactivity of local aggregates, improving the durability of concretes, and providing a database for the potential use of local materials for offshore concrete structures. This would also upgrade the local technological base for concrete testing and control.

Methods. Selected aggregates from three sources were mined, processed and shipped to a concrete-testing laboratory. Mechanical properties of concrete with up to 91-day and longer term curing periods were tested. The project was performed by Nolan, Davis & Associates Ltd.

Results. With respect to high-durability concrete, compressive-strength performance of similar mixes using the three different aggregates is comparable. Results indicate that it would be possible to make concrete achieving 75 MPa strength at 91 days with all three aggregates. Other mechanical-properties results were also acceptable for all three aggregates. The main area of concern is the freeze–thaw durability, where only the concrete incorporating the sandstone aggregate performed well. More research is needed to explain the poor performance in freezing and thawing of the concretes made with granite and gravel aggregates.

The sandstone aggregate has the superior overall performance. In the plastic concrete, the batches displayed a lower variability, and hardened concrete characteristics were comparable or superior to those of concretes made with the gravel and granite aggregates.

C.2.3 IRON-ORE PROCESSING

C.2.3.1 Iron Ore–Binders, Part I and Part II (J.M.D. Wilson)

Objectives. The specific goal of this project was to develop a substitute binder for iron-ore pellets that imparts the same pelletizing qualities as bentonite, is cheaper to use and reduces the silica content of the final pellets.

Methods. Several candidate binders supplied by various suppliers were tested both in the laboratory and in the pilot plants. Properties of green balls, as well as the physical and metallurgical quality of pellets fired in a pot-grate machine, were evaluated. Particular attention was paid to three types of the most successful potential binders, namely, Peridur, Alchem and peat moss. Potential binders were tested with various pelletizing mixtures (acid, dolomite, limestone and fully fluxed). Both parts of the project were supported by the Iron Ore Company of Canada.

Results. The best results were obtained with a new version of Peridur called Peridur C-10. Test results indicate that an acceptable pellet quality can be achieved with this binder, although economic factors are still to be considered by the company. The binder Alchem 8C26 and peat moss should only be considered on a basis of partial substitute for bentonite.

Batch-scale results indicate that with further work an organic binder may be successfully developed that will be a partial substitute for bentonite.

C.2.3.2 Iron Ore–Recovery (M.J. Stefanski)

Objectives. The purpose of this project was to raise the 70-percent iron-ore recovery rate at Wabush Mines. Increased recovery would improve productivity and reduce costs, thus improve competitiveness on the market.

Methods. A quantitative mineralogical study was based on novel sophisticated methods that to a great extent had been developed at the Canada Centre for Minerals and Energy Technology. It consisted of quantitative mineralogical analyses, liberation analyses, and mineral–metal balance of a suite of samples from grinding and spiral circuits.

Batch and small pilot tests aimed at developing an improved flowsheet were carried out at the Ontario Research Centre. They consisted of processing the Wabush material on Humphrey spirals, grinding, classifying, processing on Richert spirals and analyzing results.

Pilot-plant tests involved on-site testing of the grinding and spiral circuits at the Scully Mine concentrator. Based on the recommendation of the quantitative-mineralogy and flowsheet-development studies, spiral middlings regrind and finer mill sizing were investigated as potential ways of improving iron-unit recovery. A middlings regrind flowsheet was set up on one of six grinding mills as a prototype mill line. For optimizing the prototype circuit, an expert-control system for the grinding and spiral circuit is being developed and tested.

Wabush Mines supported the project and intends to spend much more to implement the findings on a large scale.

Results. Comparative testing of the prototype mill line with other lines showed that middlings regrind increased spiral iron-unit recovery by 1.68 percentage points without negatively affecting the recovery and grade of manganese. Progress was also made in the achievement of finer mill sizing with the installation of a finer trommel in conjunction with finer Polytech sizing screen. This also was a success as sizing-screen efficiency improved with no reduction in mill throughput. Further changes of sizing equipment will continue and tests will be carried out independently by Wabush Mines.

Wabush Mines confirms that savings achieved by introducing middlings regrind on all millcircuits as tested by this project will amount to over $600,000 a year. The payback on converting the first three mills (planned for 1989) to the new regime will be 1.7 years.

It is expected that introducing the expert-control system to grinding circuits developed in the pilot-plant tests, as well as further changing the sizing equipment, will further improve Scully Mine efficiency and lead to more important savings.

C.2.4 GOLD PROCESSING
(D.J. MacKinnon)

Objectives. The purpose of this project was to help the Hope Brook gold mine with its problem of copper-compounds buildup in the cyanide-leach solution. Introducing a new efficient electrolytic system to recover copper should have a beneficial effect on the environment and on cyanide-consumption rate. It also should lead to additional value by recovering the copper metal. The project served to determining design parameters for a copper-recovery cyanide-recycle electrolytic system.

Methods. Laboratory tests were carried out by CELEC Inc.

Results. The laboratory tests determined the following: the copper-removal rate decreases with increasing CN:Cu molar ratio; the copper-removal rate increases with increasing current density; the carbon felt cathode has a superior performance to the reticulated carbon cathode; and the technical and economic feasibility of the process needs to be confirmed using actual Hope Brook solution.

3. ECONOMIC DEVELOPMENT STUDIES

C.3.1.1 Study of Industrial Minerals Used in Oil and Gas Exploration on the Eastern Canadian Offshore

Objectives. Phase 1: A contracted project to identify the industrial minerals utilized by the offshore oil and gas exploration companies, and to describe corporate arrangements to secure these commodities.

Phase 2: A province-specific study to identify sources of acceptable materials for use in offshore-drilling programs, and to determine the quantity and quality of industrial minerals required to build and maintain a production and distribution facility, offshore and onshore.

Methods. This was a two-year cooperative study done on behalf of Newfoundland, Nova Scotia and New Brunswick. The project was contracted to Jacques Whitford and Associates Ltd.

Results. A comprehensive report was produced that deals with the specifications of drilling fluids (muds) and cements. Industrial minerals added to drilling muds to control weight, viscosity and pH include barite, hematite, bentonite, attapulgite, sylvite, calcite and mica. Various cements are used in well casing. The selection of minerals is highly well-specific, so some 60 wells, representing about one third of east-coast wells drilled since 1980, were surveyed for types of mud and cement used. Factors determining the demand for various types of drilling fluids were found to be current industry practice, hole conditions and price. Overall drilling

activity on the east coast was seen as being depressed. Consequently, market prospects were considered limited; demand and prices of drilling-fluid commodities were low.

C.3.1.2 The Newfoundland Building Stone Demonstration Project

Objectives. Phase 1: To identify specifications for building and markets within competitive reach of Newfoundland.

Phase 2: To demonstrate the technical and financial viability of quarrying, cutting and polishing building stone from six identified Newfoundland deposits.

Methods. Stone from three sites was quarried and delivered to St. John's as polished slabs of a pink granite, a megacrystic granite and fine-grained black gabbro. Phase 2 involved provision of 500 tiles from a granite property for inclusion in the new CERR building being constructed at Memorial University of Newfoundland.

Plate 12. *Polishing a slab of Deadman's Bay Granite from Lumsden for use in the CERR building.*

Results. Phase 1. The use of natural dimension-stone cladding on buildings in North American cities is growing. Architectural specifications are project-specific. Uniformity of product and reliability of supply are very important. Informal, word-of-mouth advertising is prevalent. Distance from quarry to fabricator to site, and hence transportation cost, is important, but is by no means the governing factor in the choice of stone.

Phase 2. Rock from six sites was examined and further investigations recommended for four of the sites. A development strategy for a private dimension-stone industry is formulated and the economics of stone production and dressing are discussed.

C.3.1.4 Pyrophyllite Study

Objectives. The purpose of this project was to identify markets for pyrophyllite, to determine specifications for all uses, to identify quantities used and prices paid for various grades, to illustrate delivery patterns and to outline opportunities for further development of provincial pyrophyllite resources.

Methods. The project was contracted to Guillett, Kriens & Kriens, who carried out a comprehensive study to determine whether a non-captive market for Newfoundland pyrophyllite exists by surveying markets for pyrophyllite in the ceramics, refractory and fillers field.

Results. The only significant use for pyrophyllite is in the manufacture of ceramic tile. Potential uses exist in pulp and paper and paint manufacture, for example, but Newfoundland pyrophyllite contains quartz and sericite, which rule out its use in these industries. If these minerals could be removed by floatation, a more readily marketable product would result. However, tests determined that this is not possible.

C.3.1.5 Opportunities in Specialty Silicas

The report was purchased jointly by Newfoundland, Nova Scotia and New Brunswick. It is the first comprehensive survey and analysis of the North American and, to a lesser extent, European markets for these speciality mineral and chemical products.

C.3.1.6 A Study of U.S. East Coast Industrial-Mineral Markets for New Brunswick, Newfoundland and Nova Scotia

Objectives. The purpose of this project was to study markets for fifteen major industrial minerals within a corridor along the U.S. east and gulf coasts, and to identify growth segments for any industrial-mineral commodity.

Methods. The project was sponsored equally by New Brunswick, Nova Scotia and Newfoundland, with each province sharing in the selection of the fifteen commodities to be addressed. The contract was awarded to Metals Economics Group in 1987.

Results. Consumers were interviewed, and market profiles were developed for the 15 industrial-mineral markets

under study. These markets are for abrasives, diatomite, dimension stone, feldspar, fluorspar, graphite, gypsum, kaolin, lime, limestone, rutile, salt, silica, sands, sillimanite and sulphur. Limited profiles for ilmenite, rare earths and yttrium, slate, wollastonite and zircon were also produced.

C.3.1.7 Opportunities in High-Growth Metals

The report was purchased jointly by Newfoundland, Nova Scotia and New Brunswick. It is the first comprehensive survey and analysis of the U.S. markets for 14 specialty metals in five major end uses.

C.3.1.8 Offshore Development Planning Phase 1

Objectives. The purpose of this project was to facilitate offshore non-fuel mineral development by providing industry and resource managers with baseline information on regional geology, mineral distribution and potential concerns with respect to fisheries and coastal erosion in Atlantic Canada.

Methods. Planning and contract administration are co-ordinated by the Ocean Mining Division, Energy, Mines and Resources, in cooperation with the Newfoundland Department of Mines and Energy, the federal Department of Fisheries and Oceans and relevant EMR agencies. This is a two-year, three-phase program.

Results. The project is a compilation of 10,493 sample data entries of seafloor samples and seismic data collected in the nearshore areas of the Atlantic Provinces. Sample density is highly variable; there is no seismic coverage adjacent to Newfoundland, for example. Samples were taken for reasons other than for resource evaluation, so potentially economic sediments were not specifically identified. Nevertheless, economic minerals have been identified in some areas. Newfoundland beach sands do not show unusual assemblages of heavy minerals. The compilation serves as a starting point for firms interested in the economic potential of the offshore.

C.3.1.10 Slate Market Study

Objectives. The purpose of this project was to study the slate industry as it pertains to Newfoundland and to prepare a comprehensive report detailing such items as market access, specification, prices, substitutes and transportation costs, as well as a marketing strategy for the industry.

Methods. The contract was awarded to Atlantic Consulting Economists Ltd. The survey is based on material provided by the industry and by various government bodies, accessed via the overseas Canadian trade posts. As well, information was derived by mail, phone and individual meetings.

Results. Newfoundland slate is of good quality, but Canadian demand for roofing and for dimension slate is small. Any expansion of Newfoundland production would have to be in exports. However, there is a great variety of slate products available world wide, and there are many slate producers. Any prospective new producer would need to consider the various aspects of the international market that are discussed in this comprehensive report.

C.3.1.11 Brick Market Study

Objectives. The purpose of this project was to study the markets for brick in Newfoundland in order to determine product demand, distribution, cost and price structure, competition to the provincial producer, and whether or not future demand would support a second brick producer in the province.

Methods. A contract was awarded NORDCO Ltd. to carry out the project according to the terms of reference.

Results. The provincial brick market is small and can be met by the existing supplier. Nevertheless, some 40 percent of the market is supplied from outside, chiefly from Nova Scotia and to a small extent from Quebec. Newfoundland bricks are high cost because of high fuel costs; however, the provincial market is protected from central Canadian producers by the even higher cost transportation. The transport factor means that Newfoundland producers cannot compete out-of-province, which coupled with an anticipated low domestic demand, precludes expansion of brick making in the province.

C.3.1.12 Establishment of a Silica-Based Industry in Labrador West

Objectives. The purpose of this project was to investigate the economic and technical feasibility of establishing silica-based industries in Labrador West, utilizing local, major, high-quality deposits identified by the Newfoundland Department of Mines and Energy.

Methods. A contract was awarded to Fenco. Detailed data were difficult to acquire because of the extreme secrecy in the high-grade, high-value silica trade.

Results. Other MDA-sponsored work indicated two very high-quality quartz deposits in the vicinity of Labrador City. This report examines the feasibility of establishing a silica-based industry on the deposits.

An overview was made of markets for ferrosilicon, silicon and silicon carbide; electric-furnace smelting processes were described and costed. Analysis indicates that a feasibility study into the production of silicon metal would be worthwhile.

C.3.1.13 Extender and Filler Minerals

The three-volume report was purchased jointly by Newfoundland, Nova Scotia and New Brunswick. One volume per year, beginning in 1987, was produced. Each volume covered a particular set of extender and filler-minerals consumers.

It is hoped that identification of potential market opportunities for filler and extender minerals capable of being produced in Newfoundland will allow existing and prospective producers to diversify into new product lines.

APPENDIX A

CANADA-NEWFOUNDLAND

MINERAL DEVELOPMENT AGREEMENT, 1984-1989

PART A: PROVINCIAL OUTPUTS

PART B: FEDERAL OUTPUTS

PART A: PROVINCIAL OUTPUTS

1. GEOSCIENCE

J.1.8 INDUSTRIAL MINERAL STUDIES

J.1.8.1 Industrial Minerals (A.F. Howse)

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J.1.10 ANALYTICAL AND OTHER TECHNICAL SERVICES

J.1.10.1 Analytical Support (H. Wagenbauer)

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J.1.10.3 Administrative Support (W. Ryder)

(Financial statements and sundry support)

J.1.10.4 Cartography (K. Byrne)

(Provided cartographic and photomechanical services to publications and related material generated by other projects under the Agreement)

J.1.10.5 Lake-Sediment Analysis (P.H. Davenport)

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N.1.2.1 Paleontological Support (W.D. Boyce)

PUBLICATIONS

Boyce, W.D.

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N.1.4 GEOPHYSICS

N.1.4.1 Geophysical Support (G.J. Kilfoil)

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N.3.1 INDUSTRIAL MINERAL COMMODITY AND INDUSTRY STUDIES

N.3.1.3 Impact of Alternative Types of Regional Development Policy (B. Hynes)

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N.3.2.1 MIAP Co-ordinator (B.F. Kean)

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N.4.1.1 Public Information (R.F. Blackwood)

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C.1.1 MINERAL-DEPOSIT STUDIES

C.1.1.1 Metallogeny, Central Mineral Belt (T.C. Birkett)

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C.1.1.3 Metallogeny of Carbonate Terrane, Western Newfoundland (D.F. Sangster; T.C. Birkett)

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C.1.1.5 Metallogeny of Newfoundland Ophiolites (J.W. Lydon)

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1986: Geological setting of sulphide mineralization at Tilt Cove, Newfoundland. *In* Current Research, Part A, Geological Survey of Canada, Paper 86-1A, page 319-325. Abstract published *in* Current Research, Newfoundland Department of Mines and Energy, Report 86-1, page 322.

1988: Ophiolitic sulphide mineralization at Tilt Cove, Newfoundland: controls by upper mantle and crustal processes. Economic Geology, Volume 83, Number 2, pages 239-255.

Zwicker, E.J. and Strong, D.F.
1986: The Great Bend ophiolite, eastern Newfoundland: field investigations. *In* Current Research, Part A, Geological Survey of Canada, Paper 86-1A, pages 393-397, 1986. Abstract published *in* Current Research, Newfoundland Department of Mines, Mineral Development Division, Report 86-1, page 324.

ORAL AND POSTER PRESENTATIONS

Dunsworth, S.
1985: The Springers Hill chromite deposit, Bay of Islands, Newfoundland. Newfoundland Department of Mines and Energy 9th Annual Review of Activities and Open House, St. John's, November, 1985.

Dunsworth, S.M. and Calon T.J.
1986: Magmatic and structural history of the Lewis Hills Massif and associated chromite mineralization, Bay of Islands ophiolite, Newfoundland. Newfoundland Department of Mines and Energy 10th Annual Review of Activities and Open House, St. John's, November, 1987.

1986: The Mount Barren assemblage of the Lewis Hills Massif, Bay of Islands ophiolite: not a fossil oceanic fracture zone. Newfoundland Department of Mines and Energy 10th Annual Review of Activities and Open House, St. John's, November, 1986.

1987: The Mount Barren assemblage of the Lewis Hills Massif, Bay of Islands ophiolite: not a fossil oceanic fracture zone. Geological Association of Canada-Mineralogical Association of Canada Joint Annual Meeting, Saskatoon, Program with Abstract, Volume 12, page 39.

1988: Field relations in the Lewis Hills Massif, Bay of Islands ophiolite: a history of synkinematic, multiple intrusive oceanic crustal accretion. Geological Association of Canada-Mineralogical Association of Canada-Canadian Society of Petroleum Geologists Joint Annual Meeting, St. John's, Program with Abstracts, Volume 13, page A34.

Dunsworth, S., Calon, T.J. and Malpas, J.
1986: Magmatic and structural history of the Bay of Islands plutonic complex and its associated chromite-PGE mineralization. Geological Association of Canada-Mineralogical Association of Canada-Canadian Geophysical Union Joint Annual Meeting, Ottawa, Program with Abstracts, Volume 11, page 66.

Edwards, S.J.
1987: Melt generation and evolution in ophiolite mantle. Geological Association of Canada-Mineralogical Association of Canada Joint Annual Meeting, Saskatoon, Program with Abstracts, Volume 12, page 41.

1988: Melt generation and evolution in ophiolite mantle and the development of mantle heterogeneities. Geological Association of Canada Newfoundland Section, 1988 Annual Technical Meeting, St. John's, November, 1988. Abstract published *in* Maritime Sediments and Atlantic Geology, Volume 24, No. 2, page 221.

1988: Magmatic events preserved in a mantle section of the Lewis Hills Massif, Bay of Islands ophiolite, western Newfoundland. Geological Association of Canada-Mineralogical Association of Canada-Canadian Society of Petroleum Geologists Joint Annual Meeting, St. John's, Program with Abstracts, Volume 13, page A35.

Hudson, K.A.
1986: Gold occurrences in the Betts Cove-Tilt Cove area, northwest Newfoundland. Newfoundland Department of Mines and Energy 10th Annual Review of Activities and Open House, St. John's, November, 1986.

1988: Gold/base metal mineralization and related alteration in the Nippers Harbour ophiolite, Newfoundland. Geological Association of Canada-Mineralogical Association of Canada-Canadian Society of Petroleum Geologists Joint Annual Meeting, St. John's, Program with Abstracts, Volume 13, page A58.

Lydon, J.W.
1987: Processes of platinum and gold enrichment in ophiolitic rocks of Newfoundland: some preliminary results.

Newfoundland Department of Mines and Energy 11th Annual Review of Activities and Open House, St. John's, November, 1987.

1988: The potential for hydrothermal platinum deposits. Geo-Platinum'87 Symposium, Buckinghamshire, United Kingdom, Open University, Milton Keynes, April 24, 1987. Abstract published *in* Proceedings of the Geo-Platinum 87 Symposium, pages 111-112. *Edited by* H.M. Prichard, P.J. Potts, J.F.W. Bowles and S.J. Cribb.

Lydon, J.W., Al, T., Richardson, D.G. and Lancaster, R.
1988: Processes of platinum and gold enrichment in ophiolitic rocks of Newfoundland. Geological Survey of Canada Current Activities Forum, Ottawa, January, 1988; and the 56th Annual Meeting and Convention of the Prospectors and Developers Association of Canada, Toronto, March, 1988.

Lydon, J.W. and Lavigne. J.G.
1989: Precious metal mineralization of Betts Cove ophiolite, Newfoundland. Geological Survey of Canada Current Activities Forum, Ottawa, Ontario, January, 1989; and the 57th Annual Meeting and Convention of the Prospectors and Developers Association of Canada, Toronto, Ontario, March, 5-8.

1990: Fluid penetration of magma chambers in the Bay of Islands ophiolite, and its implication for Merensky-type PGE concentration. Geological Survey of Canada Minerals Colloquim, Ottawa, January 17-18, 1990. Abstract published *in* Program with Abstracts, p. 26.

Lydon, J.W., Lavigne, J. and Carrigan, W.
1988: Investigations of potential PGE environments in Newfoundland ophiolites. Newfoundland Department of Mines 12th Annual Review of Activities and Open House, St. John's, November, 1988.

Lydon, J.W., Lovigne, J.G. and Roddick, J.C.M.
1989: The relationship of gold mineralization to the thermal and tectonic history of the Baie Verte Peninsula, Newfoundland. Newfoundland Department of Mines and Energy 13th Annual Review of Activities and Open House, St. John's, November 1989; and the Geological Survey of Canada Minerals Colloquium, Ottawa, January 17-18, 1990. Abstract published *in* Program with Abstracts, p. 26.

Lydon, J.W. and Richardson, D.G.
1988: PGE distribution in sulphide occurrences of magmatic affinity in the Bay of Islands ophiolite complex. Geological Survey of Canada Current Activities Forum, Ottawa, January, 1987; and the Geo-Platinum'87 Symposium, Buckinghamshire, United Kingdom, Open University, Milton Keynes, April 24, 1987. Abstract published *in* Proceedings of the Geo-Platinum 87 Symposium, pages 251-252, 1988. *Edited by* H.M. Prichard, P.J. Potts, J.F.W. Bowles and S.J. Cribb.

Schwann, P.L., Hudson, K.A. and Lydon, J.W.
1986: Chromite in ophiolitic complexes of Newfoundland, Bluff Head Deposit. Geological Survey of Canada Current Activities Forum, Ottawa, January 23, 1986; and the 54th Annual General Meeting and Convention of the Prospectors and Developers Association, Toronto, March, 1986.

Strong, D.F. and Saunders, C.M.
1985: Geological setting of sulphide mineralization, Tilt Cove, Newfoundland. Newfoundland Department of Mines and Energy 9th Annual Review of Activities and Open House, St. John's, November, 1985.

Suhr, G. and Calon, T.
1987: Structural history of a mantle segment in the Lewis Hills Massif (Bay of Islands ophiolite, Newfoundland). Geological Association of Canada-Mineralogical Association of Canada Joint Annual Meeting, Saskatoon, Program with Abstract, Volume 12, page 93.

1988: Structural domains in the upper mantle section of the Table Mountain Massif (Bay of Islands ophiolite), Newfoundland. Geological Association of Canada-Mineralogical Association of Canada-Canadian Society of Petroleum Geologists Joint Annual Meeting, St. John's, Program with Abstracts, Volume 13, page A121.

Talkington, R.W., Calon, T., Dunsworth, S., Malpas, J., Dahl, R. and Watkinson, D.H.
1986: Chromitite deposits of the Springer's Hill area, Bay of Islands ophiolites, Newfoundland: platinum-group element mineralogy and whole rock abundances. Geological Association of Canada-Mineralogical Association of Canada-Canadian Geophysical Union Joint Annual Meeting, Ottawa, Program with Abstracts, Volume 11, page 134.

Talkington, R.W., Watkinson, D.H. and Jones, P.
1988: Platinum-group minerals, iron nickel, and iron-cobalt alloys in chromitite, Lewis Hills Massif, Bay of Islands Complex, Newfoundland. Geological Association of Canada-Mineralogical Association of Canada-Canadian Society of Petroleum Geologists Joint Annual Meeting, St. John's, Program with Abstracts, Volume 13, page A122.

Zwicker, E.J. and Strong, D.F.
1985: Magnesite-talc mineralization in the Great Bend ophiolite, eastern Newfoundland. Newfoundland Department of Mines and Energy, 9th Annual Review of Activities and Open House, St. John's, November, 1985.

C.1.1.7 Analytical Services Support (A.G. Plant)

Analytical data/results were provided directly to project geologists.

C.1.1.8 Chetwynd Geochronology (H.S. Swinden; T.C. Birkett)

PUBLICATIONS

Dunning, G.R. and O'Brien, S.J.
1989: Late Proterozoic-early Paleozoic crust in the Hermitage flexure, Newfoundland Appalachians: U/Pb ages and tectonic significance. Geology, Volume 17, pages 548-551.

C.1.2 GEOLOGICAL INVESTIGATIONS

C.1.2.1 Geology of the Southern Long Range (K.L. Currie)

PUBLICATIONS

Currie, K.L.
1987: A preliminary account of the geology of Harry's River map area, southern Long Range of Newfoundland. *In* Current Research, Part A, Geological Survey of Canada, Paper 87-1A, page 653-662. Abstract published *in* Current Research, Newfoundland Department of Mines and Energy, Mineral Development Division, Report 87-1, page 397.

Currie, K.L. and Piasecki, M.A.J.
1989: Kinematic model for southwestern Newfoundland based upon Silurian sinistral shearing. Geology, Volume 17, pages 938-941.

Fox, D. and van Berkel, J.T.
1988: Mafic-ultramafic occurrences in metasedimentary rocks of southwestern Newfoundland. *In* Current Research, Part B, Geological Survey of Canada, Paper 88-1B, page 41-48. Abstract published *in* Current Research, Newfoundland Department of Mines, Mineral Development Division, Report 88-1, page 465.

Piasecki, M.A.J.
1987: Possible basement-cover relationships in the Fleur de Lys terrane, western Newfoundland. *In* Current Research, Part A, Geological Survey of Canada, Paper 87-1, page 391-397. Abstract published *in* Current Research, Newfoundland Department of Mines and Energy, Mineral Development Division, Report 87-1, page 395.

1988: A major ductile shear zone in the Bay d'Espoir area, Gander terrane, southeastern Newfoundland. *In* Cuurent Research. Newfoundland Department of Mines, Mineral Development Division, Report 88-1, pages 135-144.

1988: Strain-induced mineral growth in ductile shear zones and a preliminary study of ductile shearing in western Newfoundland. Canadian Journal of Earth Sciences, Volume 25, Number 12, pages 2118-2129.

van Berkel, J.T.
1987: Geology of the Dashwoods Pond, St. Fintan's and Main Gut map areas, southwest Newfoundland. *In* Current Research, Part A, Geological Survey of Canada, Paper 87-1A, page 399-408. Abstract published *in* Current Research, Newfoundland Department of Mines and Energy, Mineral Development Division, Report 87-1, page 396.

van Berkel, J.T. and Currie, K.L.
1988: Geology of the Puddle Pond (12A/5) and Little Grand Lake (12A/12) map areas, southwestern Newfoundland. *In* Current Research. Newfoundland Department of Mines, Mineral Development Division, Report 88-1, pages 99-107.

van Berkel, J.T., Johnston, H.P. and Currie, K.L.
1987: A preliminary report on the geology of the southern Long Range, southwest Newfoundland. *In* Current Research, Part B, Geological Survey of Canada, Paper 86-1B, page 157-170. Abstract published *in* Current Research, Newfoundland Department of Mines and Energy, Mineral Development Division, Report 87-1, page 386.

OPEN FILES

Currie, K.L.
1987: Geology, Harry's River area (12B/9; 12A/12), western Newfoundland. Geological Survey of Canada, Open File 1406, 1 map, scale 1:50,000.

van Berkel, J.T.
1987: Geology of Main Gut map area (12B/8), southwest Newfoundland. Geological Survey of Canada, Open File 1467, 1 map, scale 1:50,000.

1987: Geology of Dashwoods Pond (12B/1) and part of St. Fintan's (12B/2) map areas, southwest Newfoundland. Geological Survey of Canada, Open File 1466, 1 map, scale 1:50,000.

van Berkel, J.T. and Currie, K.L.
1986: Geology of the southern Long Range, southwest Newfoundland (12A/4, 5, 12; 12B/1, 2, 8, 9E). Geological Survey of Canada, Open File 1328, 1 map, scale 1:100,000.

1988: Geological map of the southern Long Range, southwest Newfoundland (12A/4, 5, 12; 12B/1, 2, 8, 9). Geological Survey of Canada, Open File 1758, 1 map, scale 1:100,000.

1988: Geology of Little Grand Lake (12A/12) and Puddle Pond (12A/5) map areas, southern Long Range of Newfoundland. Geological Survey of Canada, Open File 1738, 2 maps, scale 1:50,000.

ORAL AND POSTER PRESENTATIONS

Currie, K.L.
1988: Geology of the Southern Long Range. Newfoundland Department of Mines 12th Annual Report of Activities and Open House, St. John's, November, 1988.

Fox, D.
1987: Mafic-ultramafic occurrences in the southern Long Range Mountains, Newfoundland. Newfoundland Department of Mines and Energy 11th Annual Review of Activities and Open House, St. John's, November, 1987.

van Berkel, J.
1986: The southern Long Range, Newfoundland. Newfoundland Department of Mines and Energy 10th Annual Review of Activities and Open House, St. John's, November, 1986.

1986: Geology of the southern Long Range. Newfoundland Department of Mines and Energy 10th Annual Review of Activities and Open House, St. John's, November, 1986.

1987: Geology of the Puddle Pond (12A/5) and Little Grand Lake (12A/12) map areas, southwest Newfoundland. Newfoundland Department of Mines and Energy 11th Annual Review of Activities and Open House, St. John's, November, 1987.

van Berkel, J. and Currie, K.L.
1985: Geology of the southern Long Range. Newfoundland Department of Mines and Energy 9th Annual Review of Activities and Open House, St. John's, November, 1985; and the Canadian Tectonics Workshop, Halifax, November, 1985.

C.1.2.2 Geology of Northern Long Range (K.L. Currie)

PUBLICATIONS

Erdmer, P.
1987: Geology of the Long Range Inlier in Sandy Lake map area, western Newfoundland. *In* Current Research, Part B, Geological Survey of Canada, Paper 86-1B, page 19-27. Abstract published *in* Current Research, Newfoundland Department of Mines and Energy, Mineral Development Division, Report 87-1, page 387.

Owen, J.V.
1986: Geology of the Silver Mountain area, western Newfoundland. *In* Current Research, Part A, Geological Survey of Canada, Part 86-1A, page 515-522. Abstract published *in* Current Research, Newfoundland Department of Mines and Energy, Report 86-1, page 320.

In press: Geology of the Long Range Inlier, western Newfoundland. Geological Survey of Canada, Bulletin 395.

Owen, J.V., Campbell, J.E.M., and Dennis, F.A.R.
1987: Geology of the Lake Michel area, Long Range Inlier, western Newfoundland. *In* Current Research, Part A, Geological Survey of Canada, Paper 87-1A, page 643-652. Abstract published *in* Current Research, Newfoundland Department of Mines and Energy, Mineral Development Division, Report 87-1, page 398.

Owen, J.V. and Erdmer, P.
1986: Precambrian and Paleozoic metamorphism in the Long Range Inlier, western Newfoundland. *In* Current Research, Part B, Geological Survey of Canada, Paper 86-1B, page 29-38. Abstract published *in* Current Research, Newfoundland Department of Mines, Mineral Development Division, Report 87-1, page 388.

1988: The Grenvillian Long Range Inlier of the Great Northern Peninsula, Newfoundland. Geological Association of Canada, Field Trip Guidebook, Trip B7, May 1988, 36 pages.

1989: Metamorphic geology and regional geothermobarometry of a Grenvillian massif: the Long Range Inlier, Newfoundland. Precambrian Research, Volume 43, Numbers 1-2, pages 79-100.

In press: Middle Proterozoic geology of the Long Range Inlier, western Newfoundland: Regional significance and tectonic implications. *In* Mid-Proterozoic Geology of the Southern Margin of Proto-Laurentia–Baltica. *Edited by* C.F. Gower, T. Rivers and B. Ryan. Geological Association of Canada, Special Paper.

Owen, J.V., Greenough, J.D. and Bellefontaine, K.A.
1989: Preservation of primary geochemical signatures in polymetamorphosed tholeiite: the Long Range dyke swarm, Newfoundland. Lithos, Volume 24, pages 55-64.

Owen, J.V. and Machin, D.C.
1987: Petrography and geochemistry of some mafic dykes in the Long Range Inlier, western Newfoundland. *In* Current Research, Part A, Geological Survey of Canada, Paper 87-1A, page 305-316. Abstract published *in* Current Research, Newfoundland Department of Mines and Energy, Mineral Development Division, Report 87-1, page 399.

OPEN FILES

Erdmer, P.
1986: Precambrian geology of the northern Long Range inlier, western Newfoundland (12H). Geological Survey of Canada, Open File 1310. 1 map, 1:100,000 scale.

Owen, J.V.
1986: Geology of the Silver Mountain area, western Newfoundland (12H/11). Geological Survey of Canada, Open File 1279. 1 map, 1:50,000 scale.

1987: Geology of the central part of the Long Range Inlier, western Newfoundland (12I/2-4, 6-10). Geological Survey of Canada, Open File 1505, 1 map, 1:100,000 scale.

ORAL AND POSTER PRESENTATIONS

Erdmer, P.
1986: The Long Range Inlier of western Newfoundland: Humber Zone basement window or thrust slice? Geological Association of Canada-Mineralogical Association of Canada-Canadian Geophysical Union Joint Annual Meeting, Ottawa, Program with Abstracts, Volume 11, page 67.

Erdmer, P. and Owen, J.V.
1988: The record of five orogenies in the Long Range Inlier of Newfoundland. Geological Association of Canada-Mineralogical Association of Canada-Canadian Society of Petroleum Geologists Joint Annual Meeting, St. John's, Program with Abstracts, Volume 13, page A38.

Owen, J.V.
1985: Geology of the Northern Long Range. Newfoundland Department of Mines and Energy 9th Annual Review of Activities and Open House, St. John's, November, 1985.

1987: The geology of the Long Range Inlier, western Newfoundland. Geological Survey of Canada Current Activities Forum, Ottawa, January, 1987.

1986: Geology of the northern Long Range. Newfoundland Department of Mines and Energy 10th Annual Review of Activities and Open House, St. John's, November, 1986.

1988: Geological compilation of the Long Range Inlier, western Newfoundland (1:250,000). Newfoundland Department of Mines and Energy 12th Annual Review of Activities and Open House, St. John's, November, 1988.

Owen, J.V. and Erdmer, P.
1988: Middle Proterozoic geology of the Long Range Inlier, Newfoundland. Geological Association of Canada-Mineralogical Association of Canada-Canadian Society of Petroleum Geologists Joint Annual Meeting, St. John's, Program with Abstracts, Volume 13, page A93.

C.1.3 REGIONAL GEOCHEMISTRY

C.1.3.1 Regional Geochemical Reconnaissance, Labrador (E.H.W. Hornbrook; P.W.B. Friske)

OPEN FILES

Friske, P.W.B.
1985: Regional lake sediment and water geochemical reconnaissance data, Province of Newfoundland (Labrador) (NTS 13A parts of 3D, 2M and 12P). Geological Survey of Canada, Open File 1102. 21 maps and report.

1986: Regional lake sediment and water geochemical reconnaissance data, Labrador, parts of 14E,F, and L; 24H, I. Geological Survey of Canada, Open File 1210, 100 pages, 22 maps, scale 1:250,000.

1986: Regional lake sediment and water geochemical reconaissance data, Labrador, parts of 14C,D; 24A. Geological Survey of Canada, Open File 1209, 110 pages, 18 maps, scale 1:250,000.

1987: Regional stream sediment and water geochemical reconaissance data, northern Labrador, parts of 14L, 14M, 24I, 24P, 25A. Geological Survey of Canada, Open File 1354, 140 pages, 25 maps.

Hornbrook, E.H.W. and Friske, P.W.F.
1988: Regional stream and lake sediment and water geochemical infill survey data, Province of Newfoundland (Labrador), parts of 13J and 13O. Geological Survey of Canada, Open File 1637, 100 pages, 52 maps.

ORAL AND POSTER PRESENTATIONS

Friske, P.W.B.
1985: Regional reconnaissance geochemical surveys, Labrador. Newfoundland Department of Mines and Energy 9th Annual Review of Activities and Open House, St. John's, November, 1985.

1986: Regional reconnaissance geochemical surveys, northern Labrador. Newfoundland Department of Mines and Energy 10th Annual Review of Activities and Open House, St. John's, November 1986.

Friske, P.W.B., Hornbrook, E.H.W. and Ellwood, D.J.
1985: Regional lake sediment and water data, Province of Newfoundland (Labrador). 11th International Geochemical Exploration Symposium, Toronto, April, 1985.

1986: Regional lake sediment and water geochemical data, Province of Newfoundland (Labrador). 55th Annual General Meeting and Convention of the Prospectors and Developers Association, Toronto, March, 1986.

Hornbrooke, E.H. and Friske, P.W.B.
1989: A synopsis of national geochemical reconnaissance in Labrador. Newfoundland Department of Mines and Energy 13th Annual Review of Activities and Open House, St. John's, November 1989.

C.1.3.2 Follow-up of Regional Geochemical Anomalies (E.H.W. Hornbrook)

(Project transferred to Newfoundland Department of Mines and Energy in 1986)

PUBLICATIONS

Butler, J.
1986: Geochemical follow-up surveys, Labrador Trough. *In* Current Research. Newfoundland Department of Mines and Energy, Report 86-1, pages 221-222.

McConnell, J.
1986: Exploration geochemical studies of Labrador granitoids. *In* Current Research. Newfoundland Department of Mines and Energy, Report 86-1, pages 219-220.

ORAL AND POSTER PRESENTATIONS

Butler, J.
1985: Geochemical follow-up surveys, Labrador Trough. Newfoundland Department of Mines and Energy 10th Annual Review of Activities and Open House, St. John's, November, 1985.

McConnell, J.
1985: Exploration geochemical studies of Labrador granitoids. Newfoundland Department of Mines and Energy 10th Annual Review of Activities and Open House, St. John's, November, 1985.

C.1.3.3 Additional Analyses of Archived Samples (E.H. Hornbrook)

OPEN FILES

Hornbrook, E.H.W. and Friske, P.W.B.

1988: Regional lake sediment and water geochemical reconnaissance data, Province of Newfoundland (Labrador), parts of 13I, 13J, 13K, 13N and 13O. Geological Survey of Canada, Open File 1636, 150 pages, 47 maps.

1989: Regional lake sediment and water geochemical reconnaissance data, Province of Newfoundland (Labrador, parts of 23I, 23J and 23O). Geological Survey of Canada, Open File 2037, 185 pages, 47 maps.

C.1.4 GEOPHYSICS

C.1.4.1 Airborne Gamma Ray Spectrometer and VLF Surveys (K.A. Richardson)

PUBLICATIONS

Geological Survey of Canada

1986: Colour gamma ray spectrometry, Tasisuak Lake, Labrador-Quebec. Maps 35001G (14D/SW) and 35002G (14D), scale 1:250,000.

1987: Colour gamma ray spectrometry maps, Burgeo-Red Indian Lake, Newfoundland. Map 35005G, consisting of a set of seven 1:250,000 scale colour spectrometric maps (7 parameters), covering NTS 11P/9, 10, 11, 14, 15, 16 and 12A/1, 2, 3).

1987: Geophysical series map of an airborne gamma ray spectrometric, VLF and magnetic survey, southwestern Newfoundland. 1:50,000 radiometric contour maps with accompanying 1:50,000 stacked profile booklets, including maps: 35112(13)G-Corner Brook; 35112(12)G-Little Grand Lake; 35112(05)G-Puddle Pond, 35112(04)G-King George IV Lake; 36611(13)G-Peter Snout; 36611(12)G-Burgeo; 35212(09)G-Harry's River; 35212(08)G-Main Gut; 35212(01)G-Dashwoods Pond; 36511(16)G-La Poile River; 35212(07)G-Flat Bay; 35212(02)G-St. Fintan's; 36511(15)G-Grandy's Lake; 36511(10)G-Rose Blanche; 36511(11)G-Port aux Basques; and map 39004G, scale 1:250,000, VLF total field and quadrature profile maps of entire survey area.

1988: Gamma ray spectrometer survey with VLF and magnetics in the Belleoram-Gander Lake area of Newfoundland. 1:50,000 radiometric contour maps with accompanying booklets of stacked profiles, including maps: 35402(02)G–Meta Pond; 35402(03)G–Mount Sylvester; 35402(04)G–Twillick Brook; 35402(06)G–Great Gull Lake; 35402(07)G–Kepenkeck Lake; 35402(08)G–Port Blandford; 35402(09)G–Glovertown; 35402(10)G–Dead Wolf Pond; 35402(11)G–West Gander River; 36301(09)G–Harbour Buffett; 36301(10)G–Terrenceville; 36301(11)G–Belleoram-Pointe Enragee; 36301(12)G–Gaultois–Harbour Buffett; 36301(13)G–St. Alban's; 36301(14)G–Hungry Grove Pond; 36301(15)G–Gisborne Lake; 36301(16)G–Sound Island; 36611(08)G–Pass Island-Facheux Bay; and VLF total field and quadrature profile maps at scale 1:250,000 of south-central Newfoundland survey area.

1988: Airborne gamma ray spectrometric, VLF and magnetic survey, Great Northern Peninsula area, Newfoundland. 1:50,000 radiometric contour maps with accompanying booklets of stacked profiles, including maps: 35812(05)G-E 1/4-Lomond; 35812(06)G-NW 1/4-Cormack; 35812(10)G-W 1/2-Hampden; 35812(11)G-Silver Mountain; 35812(12)G-E 1/4-Gros Morne; 35812(13)G-E 1/4-St. Pauls Inlet; 35812(14)G-Main River; 35812(15)G-W 1/2-Jackson's Arm; 35912(02)G-Cats Arm River; 35912(03)G-Indian Lookout; 35912(04)G-E 1/4-Portland Creek; 35912(06)G-Bellburns; 35912(07)G-Harbour Deep; 35912(08)G-W 1/2-Great Harbour Deep; 35912(09)G-Englee; 35912(10)G-Torrent River; 35912(11)G-SE 2/3-Port Saunders; 35912(15)G-E 2/3-Castors River; 35912(16)G-W 2/3-Roddickton; and 1:250,000 VLF total field and quadrature profile maps of the entire survey area.

OPEN FILES

1989: Preliminary release of airborne gamma ray spectrometric colour maps at 1:250,000 scale, Baie-Verte area, Newfoundland, parts of 2E, 2L, 12H, 12I. Geological Survey of Canada Open File 1993, 10 colour maps and booklets of stacked profiles.

ORAL AND POSTER PRESENTATIONS

Airborne Geophysics Section, Geological Survey of Canada, and Non-Renewable Resources Group, Canadian Centre for Remote Sensing

1989: Airborne geophysics and radar surveys, Newfoundland. Newfoundland Department of Mines and Energy 13th Annual Review of Activities and Open House, St. John's, November 1989.

Ford, K.L.

1987: Ternary radioelement map of southwest Newfoundland. Newfoundland Department of Mines and Energy 11th Annual Review of Activities and Open House, St. John's, November, 1986; and the 55th Annual Meeting and Convention of the Prospectors and Developers Association of Canada, Toronto, 1987.

Ford, K.L., Shives, R.B.K., Carson, J.M., Grant, J.A., Holman, P.B. and Hetu, R.

1989: Applications of regional airborne gamma-ray spectrometry in the Appalachian region of Canada. 28th International Geological Congress, Washington, D.C., July 11, 1989. Abstract published *in* IGC Abstracts, Volume 1.

Richardson, K.A.

1988: Applications of regional airborne gamma ray spectrometry to geological mapping and mineral deposit studies. Newfoundland Department of Mines 12th Annual Review of Activities and Open House, St. John's, November, 1988.

C.1.4.2 Aeromagnetic, Gradiometer, VLF-EM Surveys (E.E. Ready)

PUBLICATIONS

Geological Survey of Canada

1986: High aeromagnetic total field and vertical gradiometer surveys of the Lake Ambrose area, Newfoundland. Maps: 21121G to 21136G, scale 1:25,000-aeromagnetic total field; 41121G to 41136G, scale 1:25,000-vertical gradient; C21137G to C21141G, scale 1:50,000-combined aeromagnetic total field and VLF EM total field profiles; and C41137G to C41141G, scale 1:50,000, combined aeromagnetic vertical gradient and VLF-EM quadrature profiles.

1988: High resolution aeromagnetic total field and vertical gradiometer surveys of the Springdale area, Newfoundland. 1:25,000 scale aeromagnetic total field maps 21313G to 21331G; 1:25,000 scale vertical gradient maps 41313G to 41331G; 1:50,000 scale combined aeromagnetic (residual total field) and VLF-EM total field profiles-C21332G to C21337G; 1:50,000 scale combined aeromagnetic vertical gradient and VLF-EM quadrature profiles-C41332G to C41337G.

Tod, J. and Ready, E.E.

1989: Aeromagnetic total field/gradiometer, VLF survey, central Newfoundland, 1986/87. *In* Current Research. Newfoundland Department of Mines, Report 89-1, pages 279-282.

1989: Aeromagnetic total field, gradiometer, and VLF-EM survey of part of the Dunnage Zone, central Newfoundland. *In* Current Research, Part B, Geological Survey of Canada, Paper 89-1B, page 23-27. Abstract published *in* Current Research. Newfoundland Department of Mines and Energy, Geological Survey of Newfoundland, Report 89-1, pages 307.

ORAL AND POSTER PRESENTATIONS

Ellis, B., Stone, P., Ready, E., Teskey, D.J. and Tod, J.

1990: Aeromagnetic/gradiometer/VLF-EM surveys, New Brunswick, Newfoundland and Nova Scotia. Geological Survey of Canada Minerals Colloquium, Ottawa, January 17-18, 1990. Abstract published *in* Program with Abstracts, p. 19.

Geological Survey of Canada Aeromagnetic Contract Survey Group

1988: Aeromagnetic total field, gradiometer, VLF surveys, Newfoundland. Geological Survey of Canada Current Activities Forum, Ottawa, January 1988.

Hood, P.

1985: Aeromagnetic gradiometer surveys. Newfoundland Department of Mines and Energy 9th Annual Review of Activities and Open House, St. John's, November, 1985.

Tod, J. and Ready, E.E.

1988: Aeromagnetic total field/gradiometer, VLF survey, central Newfoundland. Newfoundland Department of Mines 12th Annual Review of Activities and Open House, November, 1988.

1989: Newfoundland Mineral Development Agreement-Aeromagnetic total field/gradiometer/VLF survey, 1986-87. Geological Survey of Canada Current Activities Forum, Ottawa, Ontario, January 16-18, 1989.

C.1.4.3 Geophysical Tests of Selected Mines (P.G. Killeen; C.J. Mwenifumbo)

PUBLICATIONS

Mwenifumbo, C.J.

1987: Mise-à-la-masse experiments in the MacLean extension orebody. *In* Buchans Geology, Newfoundland. *Edited by* R.V. Kirkham. Geological Survey of Canada, Paper 86-24, pages 251-261, Report 15.

Mwenifumbo, C.J. and Killeen, P.G.

1987: Natural gamma ray logging in volcanic rocks: the Mudhole and Clementine base metal prospects. *In* Buchans Geology, Newfoundland. *Edited by* R.V. Kirkham. Geological Survey of Canada, Paper 86-24, pages 263-272, Report 16.

Sinha, A.K. and Stephens, L.E.

1987: Deep multifrequency and transient electromagnetic surveys near Buchans. *In* Buchans Geology, Newfoundland. *Edited by* R.V. Kirkham. Geological Survey of Canada, Paper 86-24, pages 235-250, Report 14.

ORAL AND POSTER PRESENTATIONS

Killeen, P.G. and Mwenifumbo, C.J.

1987: Borehole geophysics, application of new techniques to exploration. 55th Annual Meeting and Convention of the Prospectors and Developers Association of Canada, Toronto, March, 1987.

Killeen, P.G. and Schock, L.D.

1987: Making borehole geophysics quantitative: development of calibration facilities. Geological Survey of Canada Current Activities Forum, Ottawa, January 1987; and the 55th Annual Meeting and Convention of the Prospectors and Developers Association of Canada, Toronto, March, 1987.

Mwenifumbo, C.J.

1985: Downhole geophysics results, Newfoundland Zinc Mine. Newfoundland Department of Mines and Energy 9th Annual Review of Activities and Open House, St. John's, November, 1985.

C.1.5 OVERBURDEN STUDIES

C.1.5.1 Glacial History and Drift-Prospecting Studies, Labrador (R.A. Klassen)

PUBLICATIONS

Bolduc, A.M., Klassen, R.A., and Evenson, E.B.

1987: Cobble lithologies in eskers of central Labrador. *In* Current Research, Part A, Geological Survey of Canada, Paper 87-1A, page 43-51. Abstract published *in* Current Research, Newfoundland Department of Mines and Energy, Mineral Development Division, Report 87-1, page 389.

Klassen, R.A.
1987: Relationship between glacial history and drift composition. Journal of Geochemical Exploration, Volume 29, pages 421-422.

Klassen, R.A. and Bolduc, A.M.
1986: Ice flow trends and drift composition, Flowers River area, Labrador. *In* Current Research, Part A, Geological Survey of Canada, Paper 86-1A, page 697-702. Abstract published *in* Current Research, Newfoundland Department of Mines and Energy, Mineral Development Division, Report 86-1, page 317.

Klassen, R.A. and Thompson, F.J.
1987: Ice flow history and glacial dispersal in the Labrador Trough. *In* Current Research, Part A, Geological Survey of Canada, Paper 87-1A, page 61-71. Abstract published *in* Current Research, Newfoundland Department of Mines and Energy, Mineral Development Division, Report 87-1, page 390.

1988: Glacial studies in Labrador. *In* Current Research, Part C, Geological Survey of Canada, Paper 88-1C, page 109-116. Abstract published *in* Current Research, Newfoundland Department of Mines, Mineral Development Division, Report 88-1, page 464.

1989: Ice flow history and glacial dispersal patterns, Labrador. *In* Drift Prospecting. *Edited by* R.N.W. Dilabio and W.B. Coker. Geological Survey of Canada, Paper 89-20, pages 21-29.

Thompson, F.J. and Klassen, R.A.
1986: Ice flow directions and drift composition, central Labrador. *In* Current Research, Part A, Geological Survey of Canada, Paper 86-1A, page 713-717. Abstract published *in* Current Research, Newfoundland Department of Mines and Energy, Mineral Development Division, Report 86-1, page 318.

OPEN FILES

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1986: Till geochemistry, Flowers River area, Labrador (15 maps at 1:100,000 scale). Geological Survey of Canada, Open File 1282.

Klassen, R.A. and Paradis, S.
In press: Surficial geology of western Labrador, NTS 23A, 23B, 23G, 23J, 23I and portions of 13L, 22P and 23H. Geological Survey of Canada, Open File 2198, 8 maps.

Klassen, R.A. and Thompson, F.J.
1990: Glacial history, drift composition and till geochemistry, Labrador. Geological Survey of Canada, Open File 2170, Five parts—report, appendices and maps with databases available on 5¼'' floppy disks.

Thompson, F.J., Klassen, R.A. and Burns, R.K.
1986: Till geochemistry, Rigolet, Labrador (13J). Geological Survey of Canada, Open File 1318, 10 maps.

1986: Till geochemistry, Snegamook Lake, Labrador (13K). Geological Survey of Canada, Open File 1319, 17 maps.

1986: Till geochemistry, Kasheshibaw Lake, Labrador (13L). Geological Survey of Canada, Open File 1320, 16 maps.

1988: Till geochemistry, Dyke Lake, Quebec-Newfoundland (Labrador) (23NE). Geological Survey of Canada, Open File 1901, 11 maps (1:500,000).

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Bolduc, A.M., Evenson, E.B. and Klassen, R.A.
1988: Transport distances of coarse debris during esker formation: an inisght from eskers in Labrador. Geological Association of Canada-Mineralogical Association of Canada-Canadian Society of Petroleum Geologists Joint Annual Meeting, St. John's, Program with Abstracts, Volume 13, page A12.

1988: A model for the formation of the Lac Brisson esker, Quebec–Labrador: based on detailed compositional and morphological analysis. Annual Meeting of the Geological Society of America, Denver, Colorado, Program with Abstracts, Volume 20, Number 7, page A285.

Bolduc, A.M., Klassen, R.A. and Evenson, E.B.
1989: Glacial and fluvioglacial transport of peralkaline debris: Lac Brisson esker. Geological Association of Canada-Mineralogical Association of Canada Annual Meeting, Montreal, Program with Abstracts, Volume 14, page A131.

Klassen, R.A.
1985: Relationship between glacial history and drift composition. The Association of Exploration Geochemists 11th International Geochemical Exploration Symposium, Toronto, Program and Abstracts, page 65.

1985: Dispersal centres of the Laurentide ice sheet in Labrador and eastern Quebec. Geological Association of Canada-Mineralogical Association of Canada Joint Annual Meeting, Fredericton, Program with Abstracts, Volume 10, page A31, 1985.

1986: Glacial history and drift composition in Labrador. Geological Survey of Canada. Current Activities Forum, Ottawa, January 20-21, 1986.

1987: Glacial history of central Labrador. Geological Association of Canada, Newfoundland Section Meeting, St. John's, March 19-20, 1987.

1988: Glacial history and ice flow trends: a basis for drift prospecting. 56th Annual General Meeting and Convention of the Prospectors and Developers Association of Canada, Toronto, March, 1988.

1988: A proposal for the late-glacial history of northern Labrador and northeastern Quebec. VI Congress de l'association québeçois pour l'etude d'quaternaire (AQQUA), Rimouski, Québec, September, 1988.

Klassen, R.A., Matthews, J.V., Jr., Mott, R.J. and Thompson, F.J.
1988: The stratigraphic and paleobotanical record of interglaciation in the Wabush region of western Labrador. Climatic Fluctuations and Man 3. Annual Meeting of the Canadian Committee on Climatic Fluctations, Ottawa, January 28-29, 1988. Abstract published *in* Program with Abstracts, pages 24-26.

Klassen, R.A. and Thompson, F.J.
1986: Quaternary studies of ice flow history and drift composition Labrador. Newfoundland Department of Mines and Energy 10th Annual Review of Activities and Open House, St. John's, November, 1986; and the Geological Survey of Canada Current Activities Forum, Ottawa, January, 1987.

1987: Glacial history and dispersal train configurations in Labrador. Geological Survey of Canada Current Activities Forum, Ottawa, January, 1987.

1987: Ice flow history and glacial dispersal patterns, Labrador. 89th Annual General Meeting of the Canadian Institute of Mining and Metallurgy, Toronto, May 5, 1987. Abstract published *in* Canadian Institute of Mining and Metallurgy Bulletin, Volume 80, Number 899, page 65, and the International Union for Quaternary Research, XII International Congress, Ottawa, Program with Abstracts, page 201.

1987: Quaternary studies of ice flow history and drift-composition, Labrador. Newfoundland Department of Mines and Energy 11th Annual Review of Activities and Open House, St. John's, November, 1987.

1988: Regional and detailed patterns of glacial dispersal, Labrador. Geological Survey of Canada Current Activities Forum, Ottawa, January 1988.

1988: The glacial history and Quaternary stratigraphy of Labrador. Geological Association of Canada-Mineralogical Association of Canada-Canadian Society of Petroleum Geologists Joint Annual Meeting, St. John's, Program with Abstracts, Volume 13, page A67.

1989: The Payne Centre and a late-glacial ice stream in southern Labrador. Geological Association of Canada-Mineralogical Association of Canada Annual Meeting, Montreal, Program with Abstracts, Volume 14, page A131.

1989: A Quaternary geological framework for drift prospecting in Labrador: Studies of glacial history and drift composition. Newfoundland Department of Mines 13th Annual Review of Activities and Open House, St. John's, November 1989.

1990: The effects of postglacial weathering on till geochemistry, Labrador. Geological Survey of Canada Minerals Colloquium, Ottawa, January 17-18, 1990. Abstract published *in* Program with Abstracts, page 25.

1990: Regional till geochemistry of Labrador: An interpretive approach for mineral exploration. Geological Survey of Canada Minerals Colloquium, Ottawa, January 17, 1990. Abstract published *in* Program with Abstracts, page 8.

Klassen, R.A., Thompson, F.J. and Bolduc, A.M.
1986: Regional Quaternary studies in Labrador. Newfoundland Department of Mines and Energy 10th Annual Review of Activities and Open House, St. John's, November 1985; and the Geological Survey of Canada, Current Activities Forum, Ottawa, January, 1986.

C.1.5.2 Surficial Geology, Labrador (R.A. Klassen)

(Project transferred to Newfoundland Department of Mines and Energy in 1986)

PUBLICATIONS

Batterson, M. and LeGrow, P.
1986: Quaternary exploration and surficial mapping in Letitia Lake area, Newfoundland. *In* Current Research. Newfoundland Department of Mines and Energy, Mineral Development Division, Report 86-1, pages 257-265.

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Batterson, M. and LeGrow, P.
1985: Quaternary mapping and drift exploration in the Letitia Lake area, Labrador. Newfoundland Department of Mines and Energy 9th Annual Review of Activities and Open House, St. John's, November 1985.

2. MINING AND MINERALS TECHNOLOGY*

C.2.1 DEPOSIT ASSESSMENT

C.2.1.1 Selection of Mineral Deposits in Newfoundland Suitable for Research

OPEN FILES

Nolan, Davis and Associates Limited
1986: Selection of mineral deposits in Newfoundland suitable for research. 44 pages plus appendices. M.O.N. 86-540

C.2.1.2 Evaluation of Point Leamington Deposit–Phase I: Sampling

OPEN FILES

Nolan, Davis and Associates Limited
1986: Evaluation of Point Leamington deposit–Phase I: Sampling. 7 pages plus appendices. M.O.N. 86-6113

C.2.1.3 Evaluation of the Point Leamington Deposit–Phase II: Mineralogy and Small Pilot Tests

OPEN FILES

Noranda Research Centre
1988: Evaluation of Point Leamington Deposit–Phase II: Mineralogy and small pilot tests. 22 pages plus tables, figures and appendices. M.O.N. 88-3147

C.2.1.4 Assessment of Silica Deposit

OPEN FILES

Golder Associates
1987: Assessment of silica deposit. 24 pages plus appendices. M.O.N. 87-402

C.2.2 EVALUATION OF AGGREGATES

C.2.2.1 Evaluation of Aggregates for Potential Alkali-Reactivity

OPEN FILES

Golder Associates
1989: Evaluation of aggregates for potential alkali-reactivity. 63 pages plus appendices. M.O.N. 90-1337

C.2.2.2 Mechanical Properties and Long-Term Durability of Concrete with Local Aggregates and Cements for Potential Applications in Offshore Structures

OPEN FILES

Nolan, Davis and Associates Limited
1989: Mechanical properties and long-term durability of concrete with local aggregates and cements for potential applications in offshore structures. 3 pages

C.2.3 IRON-ORE PROCESSING

C.2.3.1 Iron Ore–Binders

OPEN FILES

Iron Ore Company of Canada
1986: Part 1: Development of a substitute binder for bentonite. 70 pages plus table and appendices. M.O.N. 86-5136

1988: Part 2: Study to select and optimize substitutes for bentonite. 53 pages plus tables and appendices. M.O.N. 89-1737

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* Reports coded M.O.N. and M.N.G. are available from Energy, Mines and Resources Canada at:

Energy, Mines and Resources Canada
CANMET, LDSD
562 Booth Street
Ottawa, Ontario
K1A 0C1

* Reports coded M.O.N. are also available in microfiche or as xerographic paper copies from:

MICROMEDIA Ltd.
165 Hotél de Ville
Place du Portage
Hull, Québec
J8X 3X2

C.2.3.2 Iron Ore–Recovery

OPEN FILES

ORTECH (formerly Ontario Research Foundation)
1988: Bench scale tests, Wabush Mines. 49 pages plus tables and figures.

Research and Productivity Council of New Brunswick
1988: Mineralogy, Wabush Mines. 205 pages plus tables and figures. M.O.N. 89-6204

Wabush Mines
1989: Pilot tests, Wabush Mines.

1990: Optimization-process control, Wabush Mines.

1990: Iron ore–recovery (Final Report).

C.2.4 GOLD PROCESSING

OPEN FILES

Celec Incorporated
1988: Gold Processing. 60 pages plus appendices. M.O.N. 89-1747

3. ECONOMIC DEVELOPMENT STUDIES*

C.3.1.1 Study of Industrial Minerals used in Oil and Gas Exploration on the Eastern Canadian Offshore

Jacques, Whitford and Associates Ltd.
1986: A study of industrial minerals used in oil and gas exploration on the eastern Canadian offshore. 122 pages plus appendices.

C.3.1.2 The Newfoundland Building Stone Demonstration Project

DPA Group Inc. and Jacques, Whitford and Associates Ltd.
1987: Phase 1: Market analysis for New Brunswick, Nova Scotia and Newfoundland dimension stone. 64 pages plus appendices.

Agricola Minerals
1988: Phase 2: The Newfoundland building stone demonstration project. 23 pages plus appendices.

C.3.1.4 Pyrophyllite Study

OPEN FILES

Guillet, G.R.
1987: Pyrophyllite market study. 103 pages.

C.3.1.5 Opportunities in Speciality Silicas

OPEN FILES

C.H. Kline and Company
1987: Opportunities in speciality silicas. 378 pages plus appendices.

* All activity under this program was carried out by private contractors. Contractors' reports may be viewed at the following offices:

Energy, Mines and Resources Canada
Mineral Policy Sector
Regional & Intergovernmental Affairs Division
460 O'Connor Street
Ottawa, Ontario, K1A 5H3

Energy, Mines and Resources Canada
Mineral Policy Sector
Suite 102, Cogswell Tower
2000 Barrington Street
Halifax, Nova Scotia, B3J 3K1

Newfoundland Department of Mines and Energy
Geological Survey Branch
P.O. Box 8700
St. John's, Newfoundland, A1B 4J6

C.3.1.6 A Study of U.S. East Coast Industrial-Mineral Markets for New Brunswick, Newfoundland and Nova Scotia

OPEN FILES

Metals Economics Group
1988: A study of U.S. East Coast Industrial-Mineral Markets for New Brunswick, Newfoundland and Nova Scotia. 654 pages.

C.3.1.7 Opportunities in High-Growth Metals

OPEN FILES

C.H. Kline and Company
1986: Opportunities in high-growth metals. 296 pages plus appendix.

C.3.1.8 Offshore Development Planning Phase I

OPEN FILES

Earth and Ocean Research Limited
1988: Compilation of information of surficial mineral resources off eastern Canada. 3 volumes.

C.3.1.10 Slate Market Study

OPEN FILES

Atlantic Consulting Economists Limited
1988: The present and future markets for slate products. 201 pages plus appendices.

C.3.1.11 Brick Market Study

OPEN FILES

Nordco Limited
1988: The market for bricks in Newfoundland. 42 pages plus appendices.

C.3.1.12 Establishment of a Silica-Based Industry in Labrador West

OPEN FILES

Fenco-Lavalin
1988: Prefeasibility study of the establishment of a silica-based industry in Labrador west. 70 pages plus appendix.

C.3.1.13 Extender and Filler Minerals

OPEN FILES

C.H. Kline and Company
1985: Volume 1: Extender and Filler Minerals North America: a continuing business review.

C.H. Kline and Company
1986: Volume 2: Paint, adhesives and sealants.

C.H. Kline and Company
1987: Volume 3: Plastics and rubber.

4. PUBLIC INFORMATION, EVALUATION AND ADMINISTRATION

C.4.1 PUBLIC INFORMATION

OPEN FILES

Mineral Development Program Office
1989: Canada-Newfoundland Mineral Development Agreement, List of outputs produced by Geological Survey of Canada during years 1984 through 1989. Geological Survey of Canada, Open File 2144, 36 pages.

ORAL AND POSTER PRESENTATIONS

Birkett, T.C.
1985: Review of projects by the Geological Survey of Canada. Newfoundland Department of Mines and Energy 9th Annual Review of Activities and Open House, St. John's, November, 1985.

Lydon, J.W.
1986: Review of projects by the Geological Survey of Canada. Newfoundland Department of Mines and Energy 10th Annual Review of Activities and Open House, St. John's, November, 1986.

Mineral Developement Program Office
1984: Index map showing location of Geological Survey of Canada projects within Newfoundland Mineral Development Agreement during 1984-85. Newfoundland Department of Mines and Energy 8th Annual Review of Activities and Open House, St. John's, November, 1984.

1985: Index map showing location of Geological Survey of Canada projects within Newfoundland Mineral Development Agreement during 1985-86. Newfoundland Department of Mines and Energy 9th Annual Review of Activities and Open House, St. John's, November, 1985.

1986: Index map showing location of Geological Survey of Canada projects within Newfoundland Mineral Development Agreement during 1986-87. Newfoundland Department of Mines 10th Annual Review of Activities and Open House, St. John's, November, 1986.

1987: Index map showing location of Geological Survey of Canada projects within Newfoundland Mineral Development Agreement during 1987-88. Newfoundland Department of Mines and Energy 11th Annual Review of Activities and Open House, St. John's, November, 1987.

1989: Index map showing location of Geological Survey of Canada projects within Newfoundland Mineral Development Agreement during 1988-89. Newfoundland Department of Mines and Energy 12th Annual Review of Activities and Open House, St. John's, Newfoundland, November, 1988.

1989: Index map showing location of Geological Survey of Canada projects within Newfoundland Mineral Development Agreement through the years 1984-1989. Newfoundland Department of Mines and Energy 13th Annual Review of Activities and Open House, St. John's, November 1989.

Poole, W.H.
1984: The New Federal-Provincial Mineral Development Agreement. Newfoundland Department of Mines and Energy 8th Annual Review of Activities and Open House, November, 1984.

C.4.2 EVALUATION*

OPEN FILES

Canada Economics Ltd.
1988: A preliminary evaluation of the Canada-Newfoundland Mineral Development Agreement.

Goss, Gilroy and Associates
1990: A final evaluation of the Canada-Newfoundland Mineral Development Agreement. 46 pages plus tables and appendices.

* Copies of these reports may be viewed at:

Energy, Mines and Resources Canada
Mineral Policy Sector
Regional & Intergovernmental Affairs Division
460 O'Connor Street
Ottawa, Ontario, K1A 5H3

Energy, Mines and Resources Canada
Mineral Policy Sector
Suite 102, Cogswell Tower
2000 Barrington Street
Halifax, Nova Scotia, B3J 3K1

Newfoundland Department of Mines and Energy
Geological Survey Branch
P.O. Box 8700
St. John's, Newfoundland, A1B 4J6

APPENDIX B

CANADA-NEWFOUNDLAND

MINERAL DEVELOPMENT AGREEMENT, 1984-1989

FINANCIAL SUMMARY

PROVINCIALLY IMPLEMENTED PROJECTS

PROGRAM 1–GEOSCIENCE:

			Funding Source	
		Expenditures	Federal	Provincial
INDUSTRIAL MINERAL STUDIES SUBPROGRAM				
J.1.8.1	Industrial Minerals	302,553		
J.1.8.2	Marine-Placer Assessment	28,860		
	Subtotal	331,413	165,706	165,706
GEOLOGICAL MAPPING SUBPROGRAM				
J.1.9.1	Strange Lake	649,078		
J.1.9.2	Eastern Grenville	751,367		
J.1.9.3	Central Labrador Granitoids	475,936		
J.1.9.4	Western Grenville Project	757,035		
J.1.9.5	South Coast–Kaegudeck	416,153		
J.1.9.6	Cambro-Ordovician Carbonates	220,063		
J.1.9.7	South Coast–Avalon	193,011		
J.1.9.8	South Coast–Gander Zone	122,966		
J.1.9.9	Geochronological Support	205,531		
J.1.9.10	Granite Metallogeny, Labrador	295,430		
J.1.9.11	Volcanogenic Sulphide Metallogeny, Victoria Lake	202,658		
J.1.9.12	Granite Metallogeny–Newfoundland	379,668		
	Subtotal	4,668,896	2,334,448	2,334,448
ANALYTICAL AND OTHER TECHNICAL SERVICES SUBPROGRAM				
J.1.10.1	Analytical Support	463,046		
J.1.10.2	Computer Support	230,411		
J.1.10.3	Administrative Support	325,053		
J.1.10.4	Cartography	281,127		
J.1.10.5	Lake-Sediment Analysis	100,000		
	Subtotal	1,399,637	699,818	699,819
GEOLOGICAL INVESTIGATIONS SUBPROGRAM				
N.1.2.1	Paleontological Support	270,446		
	Subtotal	270,446		270,446
GEOPHYSICS SUBPROGRAM				
N.1.4.1	Geophysical Support	419,286		
	Subtotal	419,286		419,286

PROGRAM 1–*Continued*

		Expenditures	Funding Source: Federal	Funding Source: Provincial
OVERBURDEN STUDIES SUBPROGRAM				
N.1.5.1	Quaternary Mapping–Labrador	355,028		
N.C.1.5.1	Quaternary Mapping–Labrador	250,121		
	Subtotal	605,149	250,121	355,028
SAND AND GRAVEL SUBPROGRAM				
N.1.6.1	Aggregate-Resource Assessment	271,248		
	Subtotal	271,248		271,248
SUPPORT SERVICES SUBPROGRAM				
N.1.7.1	Analytical Support	239,030		
N.1.7.2	Computer Support	93,936		
N.1.7.3	Cartographic Support	164,509		
	Subtotal	497,475		497,475
REGIONAL GEOCHEMISTRY SUBPROGRAM				
N.C.1.3.1	Follow-up of Regional Geochemical Anomalies	161,383		
	Subtotal	161,383	161,383	
	TOTAL PROGRAM 1	8,624,933	3,611,476	5,013,456

PROGRAM 2–MINING AND MINERALS TECHNOLOGY

DEPOSIT ASSESSMENT SUBPROGRAM				
N.2.1.1	Abandoned Mine Property Assessment	515,004		
N.2.1.2	Aggregate Production	29,910		
N.2.1.3	Asbestos Institute	50,000		
	TOTAL PROGRAM 2	594,914		594,914

PROGRAM 3–ECONOMIC DEVELOPMENT STUDIES

		Expenditures	Funding Source: Federal	Funding Source: Provincial
INDUSTRIAL MINERAL COMMODITY AND INDUSTRY STUDIES SUBPROGRAM				
N.3.1.1	Asbestos Task Force	58,275		
N.3.1.2	Labradorite	20,000		
N.3.1.3	Impact of Alternative Types of Regional Development Policy	27,700		
N.3.1.4	Economic Multipliers	30,000		
N.3.1.5	Cost–Benefit Program	15,000		
N.3.1.6	Financial Cash-Flow Model	58,855		
N.3.1.7	Statistics Database	40,000		
	Subtotal	249,830		249,830
MINERAL INDUSTRY ASSISTANCE PROGRAM (MIAP)–FEDERALLY FUNDED, NEWFOUNDLAND DELIVERED				
N.3.2.1	MIAP Co-ordinator	97,293		
N.3.2.2	Prospectors Assistance Program	77,467		
N.3.2.3	Nut Cove Slate Quarry Access Road	100,000		
N.3.2.4	Granite Products Demonstration Project	50,000		
N.3.2.5	Feasibility Study for an Underground Mining Operation at Baie Verte Mine	50,000		
N.3.2.6	Feasibility/Demonstration Study on Croque Calcium Carbonate Deposits	50,000		
N.3.2.7	Conveyor Loading System at St. Lawrence Fluorspar	39,000		
N.3.2.8	Labrador Inuit Development Corporation (LIDC) Craftshop	25,900		
	Subtotal	489,660	489,660	
	TOTAL PROGRAM 3	739,490	489,660	249,830

PROGRAM 4–PUBLIC INFORMATION, EVALUATION, ADMINISTRATION

PUBLIC INFORMATION SUBPROGRAM				
N.4.1.1	Public Information	228,776		
N.4.1.2	Geoscientific Information Services	94,613		
N.4.1.3	Report Production	136,758		
	Subtotal	460,147		460,147
ADMINISTRATION SUBPROGRAM				
N.4.3.1	Administrative Support	160,007		
N.4.3.2	Accounting Support	76,795		
N.4.3.3	Management Committee–Working Group Travel	27,163		
	Subtotal	263,965		263,965
	TOTAL PROGRAM 4	724,112		724,112
TOTAL PROVINCIALLY IMPLEMENTED PROJECTS		$10,683,449	4,101,136	6,582,312

FEDERALLY IMPLEMENTED PROJECTS

PROGRAM 1–GEOSCIENCE

		Expenditures	Funding Source: Federal	Funding Source: Provincial
MINERAL-DEPOSIT STUDIES SUBPROGRAM				
C.1.1.1	Metallogeny, Central Mineral Belt	363,031		
C.1.1.2	Resource Assessment of Western Labrador	669,013		
C.1.1.3	Metallogeny of Carbonate Terrane, Western Newfoundland	344,179		
C.1.1.4	Metallogeny of Buchans–Roberts Arm Belt	386,726		
C.1.1.5	Metllogeny of Newfoundland Ophiolites	644,180		
C.1.1.6	Metallogeny, Carboniferous	2,000		
C.1.1.7	Analytical Services Support	305,401		
C.1.1.8	Chetwynd Geochronology	22,911		
	Subtotal	2,737,441	2,737,441	
GEOLOGICAL INVESTIGATIONS SUBPROGRAM				
C.1.2.1	Geology of Southern Long Range	651,667		
C.1.2.2	Geology of Northern Long Range	263,723		
	Subtotal	915,390	915,390	
REGIONAL GEOCHEMISTRY SUBPROGRAM				
C.1.3.1	Regional Geochemical Reconnaissance, Labrador	771,515		
C.1.3.2	Follow-up of Regional Geochemical Anomalies	113,000		
C.1.3.3	Additional Analyses, Archived Lake Sediments	17,538		
	Subtotal	902,053	902,053	
GEOPHYSICS SUBPROGRAM				
C.1.4.1	Airborne Gamma-ray Spectrometry and VLF	674,549		
C.1.4.2	Aeromagnetic, Gradiometer, VLF–EM	1,227,762		
C.1.4.3	Geophysical Tests of Selected Mines	21,450		
	Subtotal	1,923,761	1,923,761	
OVERBURDEN STUDIES SUBPROGRAM				
C.1.5.1	Glacial History and Drift Prospecting, Labrador	1,290,994		
C.1.5.2	Surficial Geology, Labrador	51,000		
	Subtotal	1,341,994	1,341,994	
C.1.6.1	Overhead Costs	158,220		
	Subtotal	158,220	158,220	
	TOTAL PROGRAM 1	7,978,859	7,978,859	

PROGRAM 2–MINING AND MINERALS TECHNOLOGY

		Expenditures	Funding Source: Federal	Funding Source: Provincial
DEPOSIT ASSESSMENT SUBPROGRAM				
C.2.1.1	Selection of Mineral Deposits Suitable for Research	35,200		
C.2.1.2	Evaluation of Point Leamington Deposit–Phase I: Sampling	80,600		
C.2.1.3	Evaluation of Point Leamington Deposit–Phase II: Mineralogy and Small Pilot Tests	197,200		
C.2.1.4	Assessment of Silica Deposit	134,500		
	Subtotal	447,500	447,500	
EVALUATION OF AGGREGATES SUBPROGRAM				
C.2.2.1	Evaluation of Aggregates for Potential Alkali-Reactivity	141,400		
C.2.2.2	Mechanical Properties of Concrete with Local Aggregates	4,000		
	Subtotal	145,400	145,400	
IRON-ORE PROCESSING SUBPROGRAM				
C.2.3.1	Iron Ore–Binders	283,700		
C.2.3.2	Iron Ore–Recovery	630,900		
	Subtotal	914,600	914,600	
C.2.4	Gold Processing	19,000		
	Subtotal	19,000	19,000	
	Travel	25,300		
	Subtotal	25,300	25,300	
	TOTAL PROGRAM 2	1,551,800	1,551,800	

PROGRAM 3–ECONOMIC DEVELOPMENT STUDIES

		Expenditures	Funding Source: Federal	Funding Source: Provincial
C.3.1.1	Study of Industrial Minerals used in Offshore Exploration	14,000		
C.3.1.2	Building Stone Demonstration	99,658		
C.3.1.4	Pyrophyllite	46,621		
C.3.1.5	Opportunities in Specialty Silicas	4,065		
C.3.1.6	U.S. East Coast Industrial-Mineral Markets	114,532		
C.3.1.7	Opportunities in High-Growth Metals	5,106		
C.3.1.8	Offshore Development Planning	19,882		
C.3.1.10	Slate Market	51,123		
C.3.1.11	Brick Market	27,731		
C.3.1.12	Establishment of Silica-Based Industry, Labrador West	34,700		
C.3.1.13	Extender and Filler Minerals	10,173		
	TOTAL PROGRAM 3	427,591	427,591	

PROGRAM 4–PUBLIC INFORMATION, EVALUATION, ADMINISTRATION

PUBLIC INFORMATION SUBPROGAM

C.4.1.1	Exhibits	4,400		
C.4.1.2	Brochures	14,000		
C.4.1.3	Photography	8,673		
C.4.1.4	Newsletter	19,350		
	Publication (GSC)	16,955		
	Subtotal	63,378	63,378	

EVALUATION SUBPROGRAM

C.4.2.1	Evaluation	79,081		
	Subtotal	79,081	79,081	

ADMINISTRATION SUBPROGRAM

C.4.3.1	Administration–MPS	383,323		
C.4.3.2	Administration–GSC	338,237		
	SubTotal	721,560	721,560	
	TOTAL PROGRAM 4	864,019	864,019	
TOTAL FEDERALLY IMPLEMENTED PROJECTS		$10,822,269	10,822,269	
	GRAND TOTAL	**$21,505,718**	**14,511,901**	**6,993,816**